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Practical and Theoretical Mechanics and Chemistry.

On Hydraulic and Common Mortars. By General TREUSSART, *Inspecteur du Génie. Translated from the French by J. G. Totten, Lt. Col. of Eng. and Brevet Col. United States Army.**

ART. 1. *On the present state of our knowledge of Lime.*†

Lime has been employed from time immemorial. Mixed with sand, or certain other substances, it forms what is called mortar. Although the solidity and durability of masonry depends on the goodness of mortar; still, few experiments have been made with lime; and the manner of making mortar has almost always been given up to workmen. It is only within

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†The present article is the first of a series on hydraulic and common mortars. In presenting them, the Translator thinks that he is rendering a service to the art of construction in this country.

The French, within a few years, have devoted themselves with great zeal and effect to the subject of mortars; and they have applied, with perfect success, the results of their experimental investigations, to actual constructions of great difficulty and importance. The English are, perhaps, equal to the French in knowledge of the best constituents of mortars, and in the practical composition and use of them; but they are not, like their neighbors, in the habit of recording, methodizing, and publishing their experience: and hence, though important information may be very generally spread

about fifty years that a few scientific men have attended to this important subject. Comparing the mortars of the ancients, and especially of the Romans, with those of modern times, it was perceived that the old mortars were much better than ours; and the means have, consequently, been sought of imitating them. Several constructors have thought they had discovered the secret of making Roman mortars: others, on the contrary, have thought that the Romans had no particular process, but that, of all their constructions, those only which were made of good lime had survived to our day. We shall see that my experiments tend to confirm this latter opinion.

Lime used in building, is obtained by the calcination of calcareous stones, which occur abundantly on the surface of the globe. Marbles, certain building stones, chalk, calcareous alabaster, and shells, are employed in making lime. The effect of calcination is to drive off the water and the carbonic acid which are combined with the lime. The water and the first portions of carbonic acid pass off easily; but it requires an intense, and long continued heat to dispel the remainder of the acid. Lime, as used in constructions, contains, almost always, a considerable quantity of carbonic acid.

When the stone submitted to calcination is white marble, pure lime is obtained, provided the calcination be carried far enough. According to an analysis which I made of white marble, this substance contained, in 100 parts, as follows: lime 64; carbonic acid 33; water 3. Lime obtained by calcination possesses the following properties. It has a great avidity for water, imbibes it from the air, and has its bulk enlarged thereby. If a certain quantity of water be thrown on lime recently calcined, it heats highly, breaks in pieces with noise, and a part of the water is evaporated by the heat produced. The disengaged vapour carries off some particles of lime. Water dissolves about one four-hundredth of its weight of lime, forming what is called lime-water.* Lime is caustic and turns the syrup of violets,

among their builders of all classes, it is no where to be found concentrated in books.

In this country we have been led, within a few years, to some improvements in the practice of mortar-making, by the actual necessity imposed by extensive hydraulic works, and by the providential diffusion over our territory of an admirable material; still we are, for the greater part, the slaves of an antiquated routine, elsewhere known to be radically wrong.

The works here translated are recent, and amongst the best issued from the French press: others have been carefully consulted; as Vicat's, Raucourts's, Soleirol's, &c., but these have been preferred as answering best to our need. To most American readers, they will present many new results, highly important, and of a character to be applied with great advantage to our own operations—they are, therefore, commended to the persual of all who have an interest in the subject.

In relation to the terms employed in translation, it is proper to state that the expression *fat lime*, used for the *chaux grasses* of the French, is applied to lime nearly or quite pure, not hydraulic, and which swells much in slaking. *Poor lime*, or *meagre lime*, substituted for *chaux maigres*, means a lime which slakes reluctantly, swells but little, and is not hydraulic. *Hydraulic lime*, *chaux hydrauliques*, implies a lime which will harden, in a longer or shorter time, under water—this generally slakes slowly and swells but little. The French term *ciment* means, almost always, finely pounded bricks or tiles: with us, *cement* is a sort of generic term, having various significations, but generally implying, when used herein, the hydraulic constituent of mortars

The term *Puzzalona* belongs, strictly, to a peculiar volcanic product, formerly much used in hydraulic mortars; and which is particularly referred to within; it is, however, often used to signify natural substances not volcanic, and even artificial substances, if producing effects similar to those afforded by the real *puzzalona*.

The English having adopted the expressive term *concrete*, to signify the mixture called by the French *beton*, the same term will be used in this translation.

* One four hundredth, *Davy*—one seven hundredth and fifty-eighth, *Thompson*—one seven hundredth and seventy-eight, at 60° Fahr., *Dalton*—Tr.

green: its specific gravity, according to Kirwan is 2.3, it attracts carbonic acid from the air, and finally returns to the state of carbonate of lime. To preserve it, it is necessary to keep it in very tight vessels.

Lime was formerly ranked among the alkalis, and it is only lately that the true nature of the substance became known. Davy, the English chemist, succeeded in 1807, in decomposing, by means of Volta's pile, the sulphate, and the carbonate, of lime, or more properly *lime* derived from these compounds; obtaining a brilliant substance, having so strong an attraction for oxygen that it absorbs it rapidly from the air, and from water, which it decomposes. The brilliant substance obtained from lime is regarded as a metal and has received the name of Calcium. Accordingly, lime is only a metallic oxide.

It is rare that lime derived from white marble is used in the arts; that which is commonly employed, and which is derived from ordinary lime stone, almost always contains oxide of iron, and sometimes a certain quantity of sand, alumine, magnesia, oxide of manganese, &c. Some of these substances combine with the lime by calcination: and the lime thus acquires properties which it had not before, and of which I shall speak in the sequel.

If we take lime derived from white marble, or from common lime stone, and reduce it as it comes from the kiln, to a paste with water, and if we place this paste in water, or in humid earth, it will remain soft forever. The same result will be obtained, if lime be mixed with common sand and the resulting mortar be placed in similar situations.

It is a common practice to deluge lime, fresh from the kiln, with a large quantity of water, and run it into large basins, where it is allowed to remain in the condition of soft paste. Alberti says (book II., chap. XI.) he has "seen lime, in an old ditch, that had been abandoned about 500 years, as "was conjectured from several manifest indications; which was still so moist, "well tempered, and ripe, that not honey or the marrow of animals could be "more so."

There is another kind of lime which possesses a singular property: if it be slaked as it comes from the kiln, as above, and be then placed in the state of paste, in water, or in moist earth, it will harden more or less promptly, according to the substances it contains. The same result is obtained if the lime, being mixed with sand, is made into mortar and placed in similar situations. If this lime be slaked and run into vats, as is done with common lime, it will become hard after a little time, and it will then be impossible to make use of it.

On slaking lime, fresh from the kiln, with enough water to reduce it to paste, it is found to augment considerably in bulk; this augmentation is such that one volume of quick lime will sometimes yield more than three volumes, measured in the condition of thick paste. When lime which has the property of hardening in water is slaked in the same manner, it affords a much smaller volume than common lime. Sometimes one volume of this lime, measured before slaking, will give, when slaked to thick paste, scarcely an equal bulk. For a long time, those limes which had the property of hardening in water were called *meagre limes*, and those which had not this property were called *fat limes*. These denominations were affixed because the first kind increased but little in bulk when made into paste, while the other give a considerable augmentation of volume; and because fat limes formed, with the same quantity of sand, a mortar much fatter or more unctuous than meagre lime. But the designation "*meagre lime*" is altogether improper to indicate limes which enjoy the property of hardening in

water; because there are limes which augment their volume very little, on being made into paste, and at the same time possess no hydraulic property. Belidor gave the name of béton to lime which had the quality of hardening in water; but many engineers continued to call it *meagre lime.* The denomination of *béton* is not suitable; and, in this sense, is not now in use. The following are the terms now employed.

In England, the name of *aquatic lime* has been given to lime which indurates in water; in Germany it is called *lime for the water*; Mr. Vicat, Engineer of roads and bridges, has proposed the name of *hydraulic lime*, and this denomination, which is a very good one, has been generally adopted. I shall therefore call that lime which swells considerably in slaking, *fat lime*, that which swells but little and does not harden in water, *meagre lime*, and that which possesses the property of hardening in water, *hydraulic lime*. *Fat lime* is often called *common lime*, also. The term *quick lime* is applied to all unslaked limes whether *fat lime*, *meagre lime*, or *hydraulic lime*. Although *meagre lime and hydraulic lime* may have been calcined exactly to the proper degree, still they are slower to slake, and give out less heat than *fat lime*. When *fat lime* has been too much burned, it, also, becomes slow to slake; while, if properly burned, it begins to slake the instant water is thrown on. Experiments, to be given in the sequel, will show that iron, in the state of red oxide, causes *fat lime* to slake sluggishly.

Some of the ablest chemists have, at different times, sought to detect the substances which impart to lime the property of indurating under water.

Bergman, a Swedish chemist, was, I think, the first who gave an analysis of a hydraulic lime-stone. That from Léna in Sweden, he found to contain, in 100 parts, the following substances; lime, 90; oxide of manganese, 6; clay, 4. Bergman seems to have attributed the peculiar property of hydraulic lime, to the oxide of manganese; and this opinion prevailed for a long time. On the other hand we find in the *Bibliothèque Britannique* of 1776, vol. 3, page 202, that Smeaton, the English Engineer, who built the Edystone Light-house, in 1757, attributed this property to clay: for he says that it is a curious question, which he leaves to chemists and philosophers to decide, why the presence of clay in the tissue of a calcareous stone should give it the property of hardening in water, while clay added to common lime produces no such effects.

Guyton de Morveau, announced in a memoir published in the year 9, that he had detected the presence of oxide of manganese in all the lime stones which afforded hydraulic limes; he announced, further, that in calcining together 90 parts of common lime stone pulverized, 4 parts of clay, and 6 parts of black oxide of manganese, an excellent artificial *meagre lime* would be obtained. It was stated above, that at that time, the name *meagre lime* was given to lime that would set under water; the French chemist was the first therefore to make artificial hydraulic lime; but he, as well as Bergman, was mistaken in supposing that the presence of the oxide of manganese was necessary to the result. He would have obtained his result by burning the pulverized lime stone with clay alone.

Mr. Saussure, in his *Voyage des Alpes*, says that the property possessed by certain limes of hardening in water is due solely to silex and alumine (that is to say, to clay) combined in certain proportions.

Mr. Vitalis, chemist of Rouen, made, in 1807, the analysis of the lime-stones of Senonches and St-Catherines, near Rouen; the analysis is contained in the memoir on the schists of Cherbourg (page 58) published in 1807, by Mr. Gratien, Sen., engineer of roads and bridges. This lime

stone contains, according to Mr. Vitalis, in 100 parts, the following substances, water, 12; carbonate of lime, 68; alumine, 12; sand, 6; oxide of iron, 2. In addressing these results to Mr. Gratien, senior, Mr. Vitalis expresses himself thus: "It follows from the analysis that the lime-stones of Senonches and St-Catherines, are two calcareous marles, in which the chalk predominates it is true, but wherein the clay performs an important part. It is this portion of clay which, in my opinion, makes the lime of these two lime-stones, *meagre*; whence it follows that the presence of oxide of manganese is not indispensable to the constitution of such limes, since the analysis proves that the lime-stone in question contains no oxide of manganese, as it would, if present, have coloured the glass violet." I noticed above that these hydraulic limes were then called *meagre limes*. We see that the analysis of these stones confirms the opinion of Mr. Saussure, who had attributed to the clay alone, the property of hardening in water. Thompson, an English chemist, was of the same opinion.

Mr. Descotils, engineer of mines, also made an analysis of the lime-stone of Senonches; which analysis may be found in the *Journal des Mines* of 1813, page 308. According to this trial, the Senonches lime-stone contains a quarter part of silex, disseminated in very fine particles, and only so small a quantity of iron and alumine, that these substances can have no influence on the lime; whence this engineer concludes that the hydraulic property of this lime-stone is owing to the silex. We have, however, seen above, that, according to Mr. Vitalis, it contains twice as much alumine as silex. Mr. Berthier also inserted in the *Journal des Mines* an analysis of the Senonches lime-stone, which will be given further on, and according to which the stone contains very litte alumine. This contradiction has not yet been explained. Perhaps the quarries at that place afford stones of different kinds. If so, it would be important to ascertain what is the composition of the best.

The analysis of the Senonches lime-stone afforded Mr. Descotils occasion to make an important remark on the silex contained in lime-stone: namely, that the silex found in these stones does not dissolve in acids before calcination, but does dissolve after calcination. This fact proves that the properties of silex are changed by calcination with lime, and that it combines in the dry way with this substance.

Mr. Vicat, engineer of roads and bridges, published in 1818 a very important memoir on hydraulic mortars. This engineer set out with the opinion generally admitted at that time, that it was the clay which gave to lime the singular property of hardening in water. He, in consequence, took fat lime, which he mixed with various proportions of clay, according to the following process, extracted from page 7. "The operation we are about to describe (says Mr. Vicat) is a true synthesis, reuniting in an intimate manner, by the action of fire, the essential principles which are separated from hydraulic lime, by analysis. It consists in allowing the lime, which is to be improved, to fall spontaneously to powder in a dry and covered place; afterwards to mix it, by the help of a little water, with a certain quantity of gray or brown clay, or simply with brick earth, and to make balls of this paste, which, after drying, are to be burned to the proper degree.

"Being master of the proportions, we may concieve that the factitious lime may receive any degree of energy desired, equal to, or surpassing at pleasure, the best natural lime.

"Very fat common lime will bear 0.20 of clay to 1.00 of lime; moderate-

ly fat lime will have enough clay with 0.15; and 0.10, or even 0.06, of clay will suffice for these limes which are already somewhat hydraulic. When the proportion is forced to 0.33 or 0.40, the lime does not slake, but it pulverizes easily, and gives, when tempered, a paste which hardens under water very promptly."

Such is the process indicated by Mr. Vicat. But this engineer did not content himself with experiments on a small scale: a manufactory was established near Paris by his means, where artificial hydraulic lime is made in large quantities; he moreover exerted himself to extend the use of hydraulic mortar every where, and he succeeded. He has, therefore, rendered an important service to the art of construction, and I have done him the justice to make this acknowledgment, in the notices I have heretofore published.

In 1818, Dr. John, of Berlin, presented to the Society of Sciences in Holland, a memoir, which was published in 1819. This memoir, crowned in 1818, by the Society, answered the following question proposed by the Society: "What is the chemical cause, in virtue whereof stone lime makes generally more solid and durable masonry than shell lime, and what are the means of improving shell lime in this respect?" Dr. John has remarked that shells require to be more highly calcined than common lime-stone: he thinks this owing to the shells being purer carbonate of lime than common lime-stone, which contains earthy substances facilitating the disengagement of the carbonic acid. In making the analysis of sundry lime-stones, he found that those which afforded hydraulic lime contained clay, oxide of iron, &c. He called the foreign matters which gave the property of hardening in water, *cements*; and says that it is possible, by introducing cement in the dry way to ameliorate lime which contains none. On these considerations he made the following experiments. He mixed the powder of oyster shells, 1st, with $\frac{1}{16}$ of silicious sand—2d, with several proportions of clay, varying from $\frac{1}{10}$ to $\frac{1}{3}$—3d, with $\frac{1}{40}$ of oxide of manganese. He tempered these mixtures with water, formed them into balls, let them dry in the air, and then burned them in a lime-kiln for 96 hours. The following results were obtained: the first mixture was agglutinated but friable, and was not a good result; the second mixture gave good results; and the third possessed no peculiar property. The author concludes that clay is the ingredient which gives to common lime the property of hardening in water; and he says that nothing can be easier than to procure good hydraulic lime, either from shells or from pure lime-stone, following the process indicated: he adds that it is for constructors to determine the best mixture to be made in each case.

The memoir of Dr. John contains the analysis of several ancient mortars; and offers several important observations of which I shall have occasion to speak.

In the third number of the *Annales des Mines* of 1822, there is a very interesting memoir by Mr. Berthier, *Ingénieur en Chef des mines*; it contains the analysis of different lime-stones, and several new views which will contribute to form a more perfect theory of mortars. I shall have more than one occasion to cite his experiments, and his opinion on several important facts.

Mr. Raucourt, engineer of roads and bridges, published at St. Petersburgh in 1822, a work wherein he narrates the experiments he made, following the process used by Mr. Vicat, and adding several of his own. Mr. Bergère, *chef de bataillon du génie*, gave an analysis of this work, in the *Annales des Mines* of 1824, Vol. IX.

In 1825, Mr. Hassenfratz published a memoir on mortars. This work, which is voluminous, contains many practical details on the calcination of lime-stone in different countries, and exhibits the actual state of knowledge, in the art of making mortars at the period of publication.

In terminating this reference to works on hydraulic mortars, which have appeared up to this time, I must introduce a fact, entirely new, announced by Mr. Girard de Caudemberg, engineer of roads and bridges, in a notice published by him in 1827. He states that the proprietors of mills on the river Isle, in the department of Gironde, discovered by accident, a kind of fossil sand to which they gave the name of *aréne*, which has the singular property, without any preparation, of forming, with fat lime, a mortar that hardens under water, and has great durability. I shall have occasion to return to this important fact, and to report what Mr. Girard says, as well as to state the principal experiments which have been made with this substance, in other places where it has been found.

I was employed from 1816 to 1825 at Strasburg, at which place they had made no use of hydraulic lime. I ascertained, however, that such lime was to be found in the neighbourhood. Almost all the hydraulic works connected with the fortifications of the place, having been badly constructed, and dating as far back as Vauban's time, were to be rebuilt. Twenty-five years' experience had taught me the great superiority of hydraulic mortars in the air as well as in the water—where, indeed, they are indispensable. I tried, therefore, the hydraulic limes, afforded by the environs of Strasburg, and found them excellent: they were, consquently, used in all the works both in air and water. All the revetments built from *port de Pierre* to *port Royal*, having a development of about 1650 yards, were rebuilt or repaired with hydraulic mortar. It was the same with the hydraulic works; they were rebuilt or repaired with the hydraulic lime of the neighbourhood.

An engineer who should use fat lime, even for constructions in the air, when there are hydraulic limes at hand, would be very censurable, because the expense is about the same, and, as regards the strength and durability of masonry, there is a vast difference in favour of the hydraulic mortar. But in countries where no hydraulic lime is to be had, or only that of mediocre quality, what should be done? Shall the engineer adopt the process of Mr. Vicat, which consists in making an artificial hydraulic lime? I answer, emphatically, that I think not; in this case, occurring very often, it is, in my opinion, preferable to make hydraulic mortar by a more direct process which I shall point out.

There are two modes of obtaining hydraulic mortar; the first consists in mixing natural, or artificial, hydraulic lime with sand; the second consists in mixing ordinary fat lime with certain substances such as puzzalona, trass, certain coal-ashes, and brick dust, or tile dust. I feel bound to correct here, an assertion touching these mortars, not perfectly accurate, of Mr. Gauthey, Inspector of roads and bridges. In his excellent *Treatise on the construction of bridges*, this Engineer says (Vol. II., page 278) that "fat lime is very proper for constructions out of water; but will not answer in the composition of betons to be placed in water, because the mortars in which it is used, even when mixed with puzzalona, and placed in water as soon as made, do not harden, but remain pulverulent." This is far from exact: because mortar composed of fat lime and puzzalona hardens very soon in water, and acquires, in a short time, very great strength. This fact was known to the ancients, for Vitruvius speaks of it, as will be seen further on.

I should not refer to the error into which Mr. Gauthey has fallen in this instance, if he did not enjoy a reputation so justly elevated. His highly esteemed work being in the hands of every Engineer, it was to be feared that this remark of his would prevent constructors from making hydraulic mortars by the direct union of common lime and substances analogous to puzzalona. My experiments will show that, in countries where hydraulic lime is not to be had, instead of following the process of Mr. Vicat, it is preferable to make hydraulic mortar by a direct mixture of fat lime with substances of a similar nature to puzzalona. These experiments show also that fat lime is far from being always proper for construction out of water; although Mr. Gauthey, in the beginning of the sentence, states it to be.

ART. II. *On slaking Lime; manner of making Mortar; observations on Hydrate of Lime.*

There are three modes of slaking lime. The first consists in throwing on the lime, as it comes from the kiln, enough water to reduce it to thin paste. This process is the one generally employed with fat lime. Too much water is added, almost always—that is to say, as much as is required to make it a thin cream. In this state it is run into vats; after some time it thickens, and it is then covered with a layer of sand or earth to preserve it from contact of the air, which would soon convert the upper portion into a carbonate. It is a common opinion that the longer the lime has been kept in this state, the better it is. My experiments will show that this is not true, at least not always true: since some fat lime that I had experimented with, which had been lying in this condition, gave, in the air, when the mortar was composed of lime and sand only, very bad results.

The thickening of the lime in the vats is due to the escape of water by filtration, by evaporation, and also to a third cause: for this thickening which is quite prompt, occurs equally when the vats are constructed in moist ground, and when the season is rainy. This third cause appears to me to be this: that the lime, having a strong affinity for water, solidifies the first portions very promptly, but requires a considerable time to saturate itself completely. These portions of the lime which have been too much or too little burned are, besides, slow to slake. I made the following experiment to satisfy myself on this point. I took a portion of lime that had been lying wet in a vat for four years, it was quite thick, I added a little water to bring it to the consistence of sirup, and placed it in a stoneware vessel. I took an equal portion of fat lime, slaked fresh from the kiln, reducing this also to the consistence of sirup, and placing it in a similar vessel. After a short time, this last had become very thick, while the former retained its consistence of sirup; I then added water to restore the consistence first given. The thickening again occurred, but more slowly than at first. It was necessary to add water several times before the second lime would maintain the sirupy state. It results from this experiment that fat lime, slaked into a clear paste as it comes from the kiln, retains the power of absorbing water for a considerable time.

The second method of slaking consists in plunging quick-lime into water for a few seconds. It is withdrawn before the commencement of ebullition; slakes with the water it has absorbed, and falls to powder. It is preserved in a dry place. The operation is performed with baskets into which the

lime, broken to the size of an egg, is put. Mr. de Lafaye, in 1777, proposed this mode of slaking lime, as a secret recovered from the Romans; it made much noise at the time, but experience has not realized the great results anticipated.

The third process consists in leaving the quick-lime exposed to the air. Its strong affinity for water causes it to attract the greater part of that which is in the surrounding air. Lime, thus exposed, slakes slowly without giving out much heat, and falls at last to powder. This mode of slaking is called air-slaking, or spontaneous slaking. It is employed, more or less, in several countries. It is spoken of in several works on constructions, and is generally condemned. Mr. Vicat, however, appears to give it the preference, for, at page 20 of his memoir, he says: "Such are the three modes of slaking lime: the first is generally used; the second has hardly been tried, except as an experiment at certain works; the third is proscribed, and represented, in all the treatises on construction, as depriving the lime of all energy, to such a degree that those portions which have fallen to powder in the air, are considered as lost. We shall not now speak of the processes of Rondelet, Fleuret, and others, because they do not differ much from those described. We shall see, further on, that, as regards spontaneous slaking, these proscriptions of authors who, believing every thing, repeat without examination the errors of those who preceded them, are founded on false observations and are deserving only of mistrust." Mr. Vicat has announced that a mortar made of sand, and fat lime which was air-slaked, resisted perfectly at the end of ten years, the test indicated by Mr. Berard for frost-proof stones; he says on this subject "a hint, this, to those who have written and spoken so much against air-slaking, and in opposition to the opinion which I have had to maintain singly, unable to invoke to my aid any experiments but my own." The results I have obtained are far from confirming what Vicat says, as will appear by the experiments reported hereafter.

Mr. Vicat gives, at page 20, experiments made by him to ascertain the amount of swelling of fat limes and of hydraulic limes, on slaking by the three modes. He found the first mode to be that which gave the greatest volume of paste, with both kinds of lime. On comparing the bulks obtained by the second and third modes, it was found that with fat lime, air-slaking gave greater bulk than slaking by immersion, and that it was the reverse with hyraulic lime.

At Strasburg, an attempt was made to apply, on a large scale, the mode of slaking by immersion, pointed out by Mr. Lafaye; but the process was found to be attended with inconvenience and embarrassment. It is necessary to procure a stock of baskets—to break up the larger pieces—to secure workmen who will be faithful in holding the lime under water only the given number of seconds, which is not easy; a portion of the lime is lost, falling in powder to the bottom of the vessel of water; when the lime is reduced to powder, it is requisite to measure it before making the mortar, and should there be a wind, much will be lost. These objections caused the process to be renounced in favour of that about to be described, and which amounts to the same thing.

It is founded on the following observation: if quick-lime be plunged into water it absorbs, in a certain number of seconds, a quantity sufficient to reduce it well to powder. We shall have then a like result by throwing the same quantity of water on the lime, and avoid the inconveniences attending the plunging into water. Since 1817, this process has been

employed at Strasburg, where considerable masses of lime were operated on. A small building was erected near the works, into which the hydraulic lime, not allowed to arrive too fast from the kiln, was put, to be protected from the weather; the building was boarded on the sides and top, and, in case of rain, covered with a tarpaulin. By the side of this lime-house, a larger shed was constructed, the top only being boarded; a plank floor, on which the mortar was mixed, was laid under this shed. There was a measure, without a bottom, which contained about 10 cubic feet, each dimension of the box being about 2.20 feet, this was placed on the floor and filled with lime; which being done, the same measure was used for the sand, which was placed around the lime, without covering it: with large tin watering pots of known capacity, water, equal in bulk to about one-quarter the bulk of the lime, was thrown on: the workmen knew they were to empty the watering pots but a given number of times; and the lime being all in sight they saw that they should throw the greater quantities on those parts of the heap where lay the largest lumps of lime. As soon as the slaking became energetic, the lime was left to itself until the vapours had ceased; it was then turned a little with a shovel, or a rod was thrust in, and if any lumps were found still entire, either for the want of water, or because they were too much burned, a little water was poured on these lumps. A regular form was then given to the heap, and the surface being slightly pressed with the back of the shovel, the lime was covered with the sand that had been placed around it. This process was completed towards evening—as many heaps being prepared as it was presumed would be required during the whole of the ensuing day. By thus leaving the lime, over night, in heaps, the slaking is complete; portions which have too much water impart it to those which have too little, and the water becomes thus uniformly diffused through the heap. In the morning the sand and lime of each heap were mixed together, and passed twice under the rab (rabot) before adding any water: in this way, if there were any stones, or pieces of lime imperfectly slaked, they were easily found and rejected. Water was then added in sufficient quantity to bring the whole to the state of very soft paste; because in this dilute state the mortar is, with less labour, mixed more perfectly. Experiments which follow will show that it is an error to insist that mortar should be mixed with "*the sweat of the labourers:*" it is enough if the sand be well mixed with the lime; and this mixture is better effected, and in a much more economical manner, when the mortar is in a state rather thin, than when it is thick; another reason for making it rather thin is, that it often becomes stiffer than it ought to be, before it is used, in consequence of the lime preserving, as before stated, for a considerable time, the property of solidifying water. When the lime has been properly burned, the operation just described gives a homogeneous mortar not at all granular, and not exhibiting a multitude of little white specks, which are particles of lime that have been badly slaked. At Strasburg the precaution was always taken of making up only one or two heaps of mortar at a time; so that it should not have too much time to dry before being used, and that the masons might find it in the state of paste, in the heaps in which it was deposited after being well worked. In making the mortar only as it is needed, there is, besides, the advantage of avoiding the labour of remixing, in the frequent case of the works being interrupted by rain: it is best therefore to make the heaps of slaked lime into mortar, no faster than as they are wanted. Lime may be preserved in this way for eight or ten days without losing quality. If at the end of the day, all the heaps of lime have been consumed, new heaps

should be formed for the consumption of the morrow: if a portion only have been consumed, this portion should be made good. This manner of slaking lime, and making mortar, gave very good results at Strasburg, and at other places in the vicinity where it was employed. It is seen to be a method analogous to that by immersion, recommended by Mr. Lafaye; but, by throwing upon the lime, just the quantity of water necessary to reduce it well to powder, instead of immersing it, much inconvenience and embarrassment are avoided, especially when operating with large quantities of lime.

An opportunity was presented of convincing ourselves of the goodness of mortar made by this method, it being necessary, in order to make a postern, to pierce through a revetment wall that had been built two years: the mortar had already acquired such hardness that the tools had much difficulty in cutting through the masonry.

In extensive works, it will be very advantageous, as regards economy, to make mortar with a machine. Several have been contrived with this object, but that which has succeeded best is a two-horse machine proposed and executed by Mr. Saint-Léger, formerly Captain of Engineers. The following is a brief description.

A circular trench, having the two sides sloping, is built of masonry; the section of the trench is a trapezoid 2 feet wide at bottom, 3 feet 4 inches wide at top, and 1 foot 4 inches deep; the inner circle of the trench is 9 feet 4 inches in diameter; at the centre there is a mass of masonry, in which is fixed a vertical axis, of wood, 6 feet 8 inches long, and 8 inches square, and which is bedded in the masonry about 5 feet; the top of this axis is formed into a cylinder 5 $\frac{2}{10}$ inches in diameter, and 6 inches high; around which is fitted a collar of cast-iron, carrying laterally two horizontal trunions 3 $\frac{2}{10}$ inches in diameter, and 4 $\frac{8}{10}$ inches long; a piece of wood, 26 feet 8 inches long, is notched at its middle upon the collar of the vertical axis. (Instead of one piece of wood, two might be taken, each 13 feet 4 inches long, by strongly securing, with iron, their junction with the vertical axis.) This piece is placed horizontally, and is about 13 inches square in the middle, lessening towards the ends, so as to serve as an axletree to two vertical wheels with broad felloes—6 feet diameter of wheel, and 6 inches breadth of felloe. These two wheels rest in the circular trench in such a way that the one touches the exterior and the other the interior slope of the trench. A horse is attached to each extremity of the horizontal bar, and their united efforts cause the wheels to revolve in the trench; behind each wheel, attached to the horizontal bar, by means of a hinge, is a scraper of wood armed with iron, these follow the movement of the wheels, scraping the two sides of the trench so as to throw the mortar under the wheels. These scrapers of which the lower end is within two inches of the bottom of the trench, are attached by hinges in order that they may rise over any obstacle.

Mortar is made in this machine in the following manner. A cubic metre (35.34 cubic feet) of lime in the state of paste is thrown into the trench, and the horses are started; a little water is added if necessary, and when the paste has become quite liquid and homogenous, the proper quantity of sand is thrown in by the shovel, without arresting the movement; in about 20 or 25 minutes the mortar is made. With this machine 12 batches of 3 cubic metres each ($12 \times 3 \times 35.34$ equals 1272:24 cubic feet) may be made in 10 hours labour; the reqisite agents being 4 labourers, 2 horses and their driver, and 1 superintending mason.

The expense of making a cubic metre of mortar, amounts in Paris to about $0.10; this is a considerable saving over the common mode of making mortar.* It is desirable therefore that frequent use be made of this machine, in places where there are important constructions. The description just given is extracted from the *devis-modèle* of the corps of Engineers, and was prepared by Lt. Col. Bergère of the Engineers.

It is stated above that at Strasburg, lime which was to be made into mortar, was slaked to dry powder, and left in that state for twelve hours at least before giving it the quantity of water necessary to convert it into paste. I made the following experiments with limes of the environs of Strasburg, to ascertain the volume obtained in powder and in paste, when the proper quantities of water are used to produce those states.

TABLE I.

Designation of the lime of which the volume is taken as unity.	Volume of water used to bring it first, to a state of dry powder.	Volume produced of dry powder.	Volume of water used, in all, to bring to state of paste.	Volume produced in state of paste.
Lime of white marble	$\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{6}{10}$	$1\frac{1}{2}$
Fat lime of Strasburg	$\frac{1}{2}$	$3\frac{1}{2}$	2	$1\frac{3}{4}$
Yellow lime of Obernai	$\frac{1}{2}$	2	$\frac{3}{4}$	1
Blue do. do.	$\frac{1}{2}$	$2\frac{1}{3}$	$1\frac{1}{6}$	$1\frac{1}{6}$
Brunstat lime	$\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$
Villé lime	$\frac{1}{2}$	$3\frac{1}{3}$	$1\frac{1}{2}$	$1\frac{1}{2}$
Altkirch lime	$\frac{1}{2}$	$1\frac{5}{6}$	$\frac{5}{6}$	1
Verdt lime	1	$2\frac{1}{4}$	1	1
Metz lime	$\frac{1}{2}$	$2\frac{1}{3}$	$1\frac{1}{6}$	$1\frac{1}{20}$
Boulogne pebbles	$\frac{1}{3}$	$1\frac{1}{6}$	$\frac{1}{2}$	$\frac{3}{4}$

All the limes in the above table, were used fresh from the kiln. I reduced them to powder in a mortar, sifted them, and used, for quantity, about one quart. Thus, for example, I took a measure of quick lime of white marble, and throwing upon it half a measure of water, I obtained $2\frac{1}{2}$ measures of lime slaked to powder, which I measured after it was cold. The quantity of water thrown on is shown in the second column, and the quantity of lime obtained in powder is given in the third column. I was obliged to throw upon this lime in powder, one measure and one-tenth of water in addition to reduce it to paste. Adding this last quantity of water

* One day of superintending mason, ... $0 66½
Four days of labourers, at $0 28½, ... 1 14
Two days of horses, at $0 42¾, ... 0 85½
One day of driver, ... 0 38
Wear and tear and repair for one day, ... 0 09½
Greasing wheels one day, ... 0 07
Wear and tear of shovels and barrows, 1 day for 4 labourers, . 0 07½
Contingencies, 1-10th of all, . . . 0 32

Total expense for 36 cubic metres = 1272 cubic feet $3 60

Equal to $0 10 per cub. metre—or $0:0028 per cubic foot.

The quality of the mortar is superior to that made by the common process; and it is well to remark, that the time during which the mortar is made is precisely that in which the labourers repose: it is therefore their interest to let the machine go as long as possible, and consequently to render the mortar more perfect, so that the supervision will be directed chiefly to the proportions of the mixture. This note is extracted from the devis-modèle du corps du Génie, p. 71.—Tr.

to the half measure used in the first instance, the total is $1\frac{5}{10}$ measures of water, absorbed by the lime, in being reduced to paste: this is shown in the fourth column. The fifth column shows that I obtained $1\frac{1}{3}$ measure of lime in paste. I followed the same process for all the limes of the above table, producing a uniform consistence of paste, by adding the water little by little. Experience had taught me that these limes were reduced to dry powder by throwing on one-fifth of their bulk of water; and that as much as one-half their bulk might be thrown on without the powders ceasing to be dry: beyond this term, a moist powder would be obtained. The only lime on which I threw less than half its bulk, was that at the bottom of the table, of the Boulogne pebbles; on this I poured but $\frac{1}{3}$ its bulk of water; as this lime forms a moist powder with $\frac{1}{2}$ its bulk of water, I was obliged to restrict myself to one-third. This table shows that these different limes afforded very different volumes of powder with the same quantity of water: that the quantities of water absorbed to produce the state of paste were very different, and, also, that the volumes of paste differed much. Experiments which follow will show that, of the limes in the table, those are the most hydraulic which absorbed the least water in passing to the state of paste, and which gave the smallest bulk both of powder and of paste. Those limes, of the table, which are not hydraulic, are those which gave the greatest volumes in powder and in paste. There are in the table two kinds of Obernai lime, one yellow and the other blue; they are of the same limestone, but one more highly calcined than the other. When this lime has been burned just enough, it is of a yellow-fawn colour; when a little more burned, it is of an ashy-gray, and when too much calcined, of a decided blue. It was upon the two extremes of calcination that I made the above experiments, they show that the degree of calcination has a sensible influence on the swelling of this hydraulic lime.

As the swelling of lime, shown in the above table, was obtained with quite small quantities, and with pulverized quicklime, I caused experiments to be made at the mortar beds on a large scale, with fat lime and with Obernai lime; these being the two kinds of lime ordinarily used upon the works. The following results were obtained. Fat lime was taken immediately from the kiln, and measured in the boxes in use at the mortar beds; care being taken to break up a portion of the lumps of quick lime into smaller pieces, in order to occupy the interstices between the larger pieces, and to have the measure well filled: water, in quantity sufficient to bring the lime at once to paste of the consistence of mortar, was thrown on without delay, and the quantity of paste thus obtained was measured. Proceeding thus—one measure of quicklime, just from the kiln, required two measures of water to produce the state of paste, and yielded 1.83 of paste, which differs but little from Table No. 1, wherein the produce is 1.75. The same operation was repeated with Obernai lime, after having rejected vitrified pieces, and those which had not been sufficiently calcined: one measure of this lime absorbed 1.30 of water in being reduced to paste, and in this state gave 1.30 of lime. This differs somewhat from the result in the Table.

The difference may be owing to this, that in the experiments of the Table, the lime was pulverized, and was twice slaked; that is to say had two successive applications of water, while in the larger experiment the lime was not broken up, and had water poured on but once. The degree of calcination might, also, have had some influence.

Many metallic oxides are susceptible of absorbing and solidifying a certain quantity of water forming compounds which possess peculiar properties.

It is to these compounds that the term hydrate has been assigned. It has been seen, above, that lime is a metallic oxide, and that this substance absorbs and solidifies a large quantity of water; but the quantity of water absorbed by lime in forming its hydrate is not exactly known. Berzelius asserts that the hydrates are formed of water and oxides in such proportions that the quantity of oxygen contained in the oxide is equal to the quantity of oxygen contained in the water; but Mr. Thenard does not admit this law: he says that the experiments on which it is founded are not numerous enough, nor sufficiently precise, to allow its definitive admission. It is certain nevertheless, says this celebrated chemist, that amongst the hydrates which have as yet been examined, those which contain the most water, are those, also, of which the oxides contain the most oxygen. According to Berzelius, the hydrate of lime is obtained by throwing upon quick lime the water necessary to reduce it to thin paste (*bouille,*) and exposing this paste in a silver or platina crucible to the heat of a spirit-of-wine lamp. After having dried the hydrate of lime in this manner, it is weighed, and the quantity of water it has absorbed is known by the augmentation of weight. Berzelius made two experiments, one with 10 grammes of lime and the other with 30 grammes. He found in the first experiment, that the lime had increased in weight 32.1 per cent., and in the second, 32.5: in this second experiment there was, therefore, an augmentation of four-tenths more than in the first. He attributes this difference to an absorption of carbonic acid, and he admits, as good, only the first experiment, in which 100 parts of pure lime containing 28.16 parts of oxygen, are combined with 32.1 parts of water containing 28.3 parts of oxygen; whence Berzelius concludes that the water absorbed by pure lime contains a quantity of oxygen equal to that contained in the lime.

I have repeated the experiment of Berzelius by operating on 20 grammes of pure lime, using, as he did, a spirit-of-wine lamp, and a platina crucible. I was surprised at obtaining an augmentation of only 22.5 per cent. I repeated the experiment several times, successively diminishing the thickness of the wick, and as I did this, the lime retained more and more water. I inferred, therefore, that the hydrate of lime decomposes with a feeble heat; and that, if Berzelius obtained a greater result in the second experiment than in the first, it was not all due to the absorption of carbonic acid, seeing that the operation lasts only a short time; but to this, that heating with an equal flame, two volumes of hydrate of lime, of which one was triple the other, the smaller volume should lose most water by the heat. But there is a fact which proves with how great facility the hydrate of lime abandons a part of its water. All those who have made mortar of lime newly slaked, have perceived that it becomes very dry in a short time. If, when in this state, it be worked for some time without adding water, it will be brought back nearly to the same moist state it had at first; and drops of water may be seen on the mortar. The same result is obtained with lime alone. It follows from this, that simple friction (working) decomposes the hydrate of lime, and that a feeble heat produces the same effect. To know, therefore, the quantity of water which enters into the hydrate of lime, it appears to me that other means of drying should be resorted to than fire.

The various kinds of lime are used in constructions, only after having been brought to the condition of hydrate: nothing, therefore, that relates to the properties of this compound, is a matter of indifference. As yet, few experiments have been made to determine the quantity of water that should be given to lime in making mortar. I proposed undertaking several experi-

ments on this point, but time failed me. The matter should be attended to, because, opinions are much divided thereon, for want of exact experiments.

The following are the principal properties of hydrate of lime: it is white, pulverulent, and much less caustic than quick lime; it easily abandons to heat the first portion of water, but it requires a high temperature to drive off all the water entering into its composition. This hydrate absorbs carbonic acid; experiments which follow show that it has, also, the property of absorbing oxygen, and that lime sustains important modifications in consequence of this absorption of oxygen. According to the chemists, lime is incapable of absorbing a fresh quantity of oxygen: but according to my observations, there is no doubt that the hydrate of lime absorbs a considerable quantity. I shall give, in the following Article, experiments which I made on this subject.

[TO BE CONTINUED.]

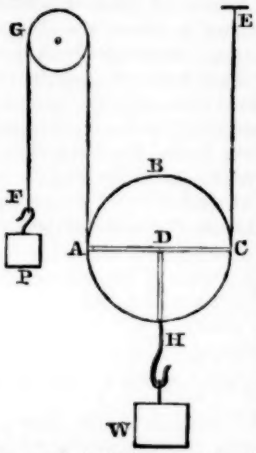
Mechanical power of the Pulley.

COMMUNICATED FOR THE JOURNAL OF THE FRANKLIN INSTITUTE. BY L. H. PARSONS

In all works on Mechanical Philosophy that I have seen, the *Pulley* is treated of as a distinct principle, so far as respects the mechanical advantage, or power, which it affords. Its efficacy is supposed to be owing, some how, to the peculiar combination of the *cords* that are used. It is sometimes indeed denominated the "*funicular* system." That a wheel or pulley, revolving on an axis, is a *lever*, in the same sense in which a common scale-beam is a lever, I suppose is never denied. But, as a lever of that description, that is, of the first kind, with the fulcrum at the centre, admits of no mechanical gain,—the velocity of the weight being equal to that of the power,—that view is obviously inadequate to the explanation of the *movable* pulley. Either the fulcrum is not at the centre, or the movable pulley does not act upon the principle of the lever. The latter conclusion is adopted. No writer, that I am aware, attempts to explain the difference in the velocity between the power and the weight, on that principle. In the Library of Useful Knowledge, it is expressly asserted (I do not quote the language) that the pulley does *not* involve the lever principle. The explanation universally given, is, that the weight being supported by the several cords attached to the movable pulley, or pulleys, the resistance is distributed equally among them; and consequently, the power being applied to only one of the cords, it encounters only that proportion of the resistance, which unity bears to the number in use.

However clear this exposition may appear to others, to me it was never satisfactory. That the resistance of a weight, supported by two or more cords of equal tension, is *divided* between those cords, is, to be sure, quite clear. The same fact, however, would be true, if the several cords were fastened directly and separately, to the weight, instead of passing over pulleys. But, (it may be answered) if all the cords were fastened to the weight no one could be *moved* in the direction of the power, without instantly encountering the whole resistance, and consequently communicating a motion to the weight, equal to that of the power. True: and why is not that the case with a pulley? Why does the power, as well as the cord to which it is attached, pass over twice as much space, as the weight passes over? Not, I apprehend, because the resistance is divided between the several cords. The two facts co-exist, in the case of a movable pul-

ley; but the one is not a consequence of, and cannot be demonstrated by, the other.



It appears to me clear, and if I mistake not, it is perfectly demonstrable, that the movable pulley *is a lever*—not of the first, but of the second kind;—with the weight between the power and the fulcrum. By considering the fulcrum at the *end* of the lever, instead of the centre,—that is, at the *side* of the pulley, where the stationary cord comes in contact with it, the difficulty disappears. The accompanying diagram, with a very few words, I think will make the matter plain. A B C is a movable pulley. The power P is obviously exerted at the point A. It must be equally obvious that the weight W rests upon the *centre* D of the pulley A B C, or of the lever A C; while the point C, of the *stationary* cord E C, serves as a fulcrum, or *centre* of *motion* to the whole pulley. C being the real centre of motion, and A being a point in the radius A C, at twice the distance of D from the centre, it follows that the velocity of A, must be double that of D.

If any doubt should remain in relation to this reasoning, let it be imagined that the *pulley* is all removed, except the *bar* A C; the other parts remaining the same as before. Would the removal of the pulley, affect the *principle* of the machine at all? Manifestly it would be the same machine, except that a circular wheel is, for such a purpose, a more perfect lever, than a straight bar; inasmuch as the bar would soon lose its horizontal position, and consequently would often need readjusting: whereas the wheel is a self adjusting lever.

It will be obvious, I think, from these remarks, that the power or efficacy of the pulley, does not reside peculiarly, in the *cords*, as is, perhaps, generally believed. The cords are, practically, an indispensable appendage; but theoretically they are not an essential element,—at least in demonstrating the principle. Suppose that, not only the pulley, but the cords were removed from the apparatus, represented above, and the point C rested on a solid abutment, instead of being supported by the cord E C; and suppose the power were applied immediately at A, would not the principle remain precisely the same?

There is one objection, which it may be proper to notice. It is said, and with truth, that even the pulley itself is not an essential part of the machine bearing that name. If, instead of passing over a pulley, the cord should pass through a ring attached to the weight, the same relative velocity between the power and the weight, and the same efficiency would exist,—setting aside friction, and the rigidity of the cord. How then, it may be asked, can a solid ring or flexible cord, or both together, constitute a lever? In the first place, it is to be observed that the *length* of a lever is of no account, in determining its efficacy. The only essential point in order to give a lever of the kind now under consideration, a power of two to one, is, to have the weight *half-way* between the power and the fulcrum. Now the point where the stationary cord comes in contact with the *ring*, is as truly a fulcrum, as if a pulley, or real lever should be interposed. And the other cord as truly exerts the power at the point where it comes in contact with the other side of the ring.—Nay, these two elements, the

power and the fulcrum, would remain, even if the *ring* should be removed and no solid body be between them. It is enough that one point is movable and the other vertically stationary, for the time being. The *loop* forms the connexion between those two points;—and passing over a ring, or other solid body, it creates a fixed and determinate relation between them and the weight, as effectually as is done by an inflexible rod.

We insert the foregoing communication, although the writer appears to labour under some misapprehensions with respect to the nature of the pulley. His views are not so clearly expressed as to leave us, in all places, perfectly free from doubt with respect to his meaning.

Several authors have explained the relation between the power and the weight in the single movable pulley on the principle of a lever of the 2nd kind: others, however, have properly objected to this mode of treating the subject, on the ground that the cord is the real mechanical power, and that the only advantage of the pulley consists in reducing the effect of friction and obviating the imperfect flexibility of the rope. Suppose the pulley to be removed and the weight attached to an infinitely fine wire crossing the rope in a direction perpendicular to the plane of its two branches, let the rope be pefectly flexible and move without friction and we have an imaginary machine in which there is the same relation between the power and weight as in the movable pulley: but here there is no lever, since the points before considered as the points of application of the power and weight respectively, now coincide, and of course move through equal distances in equal times; hence if the lever can still be supposed to exist, the power and weight having equal motions must be themselves equal, but this is contrary to the fact. If then the pulley is to be considered a lever, the cord must be a separate mechanical power; but the principle of the cord being applicable to all the varieties and combinations of the pulley, it is better to consider the pulley, as it is in fact, a mere practical convenience in the use of the cord, and theoretically in no way affecting its efficacy.

The writer of the article before us seems to consider it necessary to introduce the principle of the lever to prove that in the case of a single movable pulley the power should move through twice the distance of the weight—the fact is however clearly demonstrable in a very simple manner.

Let the power P descend 12 inches; then the branch F G will be lengthened 12 inches, and consequently the length of G H E will be diminished by the same amount; but as the weight must always take the lowest position possible, G H must always be equal to H E; hence each will be shortened 6 inches; and through this distance therefore the weight will rise.

G.

Observations on Mr. Beard's communication on the subject of belting as a substitute for gearing by wheels. By Mr. Rufus Tyler, U. S. Mint.

FOR THE JOURNAL OF THE FRANKLIN INSTITUTE.

TO THE COMMITTEE ON PUBLICATIONS.

Gentlemen,—I noticed with much satisfaction the valuable communication of I. H. Beard, Esq. on the subject of Mill Gearing, which appeared in the June number of your Journal.

I have long had a desire to see an exposition of that subject, by some one thoroughly acquainted (as the writer of that article appears to be) with the belting system as practised in the eastern cotton and woolen manufactories.

On examination of the article alluded to, I was impressed with the belief that some additional benefit might arise from a more minute investigation of several of the points there introduced, to aid in satisfying the minds of such of your readers as do not readily arrive at the rationale of mechanical operations and arrangements, especially as some of the statements appear somewhat embarrassing and likely to lead to scepticism as to the correctness of his conclusions.

I entirely agree with Mr. Beard in regard to the many advantages of the belting system over that of wheel gearing, and that "to gear a mill wholly with belts, and to do it judiciously, and to the best advantage, doubtless requires more nice calculation, careful judgment and practical experience, than to do it with gear wheels." "For many mills have been so belted as to cause more friction, trouble and expense, than would be caused or required in the use of gear-wheels."

After giving, as objectionable, one of the worst methods of arranging the main belt that ever was devised, (to wit, at page 453 in which no less than *ten* lines of drums, requiring four binders, to strain and give direction to the belt, are represented as being propelled by a single belt of great length,) he says, "in passing the drums the whole stress upon the belt is thrown upon the journals of the shaft of each drum the belt passes, which besides greatly increasing the power required to operate the mill, on account of the multiplied friction, causes the journals to heat and wear, beyond the power of any lubrication to prevent."

This passage though sufficiently explicit to convey the general idea intended by the author, leaves room for inquiry as to the relative degrees of force upon the *belt* and *journal* as well as the comparative intensities or degrees of stress upon the *different parts of the belt.*

If we raise a weight of 100 pounds by a cord or strap passing over a series of drums, (running on and off in parallel lines) the first drum in the series, or that nearest the weight, will be pressed against the bearings of the journals by a force of 200 pounds, besides the additional force upon the strap at one side of the drum, required to overcome the friction of the drum. For the strap is pulled from the drum on one side, by the weight, and on the other by an equal force required to overcome the weight, both acting in the same direction, and consequently making *one* force equal to their *sum*, which reacts upon the drum, and the additional force necessary to produce motion also re-acting in the same direction.

The tension of the strap thus increased, after passing the first drum in the series, will be thrown in *double force* upon the journals of the second, and then require a *further increase of strain* to overcome the *friction* of the *second* drum, and so on, each succeeding drum being subject to an increase of pressure upon the journals to cause friction, and is attended with an increased stress upon the strap which passes over it; in other words, each drum the strap passes, is pressed against the journals by a force equal to twice the tension of the strap, before it reaches the drum, added to the force necessary to overcome the resistance of the drum itself.

Now if there be ten drums in the series, and we suppose each one to be required to raise a weight of 100 lbs., it is evident that a much higher rate of increase will prevail in the tension of the strap in passing the succeeding drums.

Indeed, leaving out the friction altogether, the *strain*, upon the strap in passing the last drum would be ten times as great as at the first, (i. e.) 1000 pounds, and the pressure upon the journals double that intensity.

To carry out this illustration in the case of an actual belt, driving a series of drums, as represented by Mr. Beard, we may substitute (in place of weights representing the resistance to be overcome) a friction clasp or brake, at the journals of each drum, which shall be equivalent to 100 pounds resistance at the periphery of the drum, and acting in such a manner as to avoid pressing the journals against the bearings to cause friction, and let this resistance represent the ordinary operations of the mill, of which each drum performs an equal share. It is evident that after passing the first drum, the belt must be strained to the tension of 100 pounds, and on the other side only just enough to cause the necessary adhesion of the belt upon the drum, (say 50 pounds) making with the 100 pounds upon the pulling side, the sum of 150 pounds pressure on the bearings of the journals of the first drum to create friction.

Omitting for the present the friction of the journals, we shall find that on passing the second drum, the belt must be strained with 100 pounds more force, or 200 pounds upon the pulling side, which with the 100 acting to move the first drum, makes the pressure on the journals 300 pounds. We have now a tension on the belt of 200 pounds to be carried around the third drum creating a pressure of 400 pounds, to which we must add 100, arising from the increased tension of the belt requisite to make this drum revolve; making the pressure against the bearings of the third drum = 500 lbs., the tension of the belt being now 300 pounds. Proceeding in this way the pressure on the bearings of the fourth drum will be 300 + 300 + 100 = 700 pounds, the tension of the belt 300 + 100 = 400. The pressure on the fifth drum 400 + 400 + 100 = 900, tension 500; pressure on the sixth drum 500 + 500 + 100 = 1100, tension 600; pressure on the seventh drum 600 + 600 + 100 = 1300, tension 700; pressure on the eighth drum, 700 + 700 + 100 = 1500, tension 800; pressure on the ninth drum 800 + 800 + 100 = 1700, tension 900; pressure on the tenth drum 900 + 900 + 100 = 1900; tension of the belt 1000 pounds.

This accumulated stress upon the belt must next be thrown upon the *main or driving drum*, which with the necessary strain upon the other side of the main drum to cause the requisite adhesion of the belt (say 50 per cent. as at first assumed = 500 pounds, will give as the pressure upon the journals of the main drum the sum of 1500 pounds. But as the belt goes with its present strain, 500 pounds, to the next succeeding drum, which brings us round to the one we started with, where only 50 pounds is required as the tension of the belt, (and which, under a simple arrangement, would be sufficient) we have no alternative, but must add the surplus of 450 pounds to that assumed in the beginning, which taken twice makes 900 pounds *to be added* to the amount before given as the pressure upon the journals of each drum, except the main or propelling drum. Thus for the

First,	instead of	150	say	1050
Second,	"	300	"	1200
Third,	"	500	"	1400
Fourth,	"	700	"	1600
Fifth,	"	900	"	1800
Sixth,	"	1100	"	2000
Seventh,	"	1300	"	2200
Eighth,	"	1500	"	2400
Ninth,	"	1700	"	2600
Tenth,	"	1900	"	2800
Total amount of friction		10050		19050

From what has been shown, we learn how vastly more important it is to avoid all unnecessary resistance at the drums which are remote in the train, than it is with drums situated near the propelling power.

It will be perceived likewise, that if the several drums before mentioned had each a separate belt direct from the main drum, none of them would have more than 150 pounds pressure upon the journals, and therefore that the aggregate amount would be only 1500 instead of 19050 pounds; and were it practicable to carry out the plan of throwing the strain of one belt into that of another as is sometimes done in particular instances, and as is recommended by Mr. Beard (page 455) in the communication before us, the whole amount of pressure, upon the journals of all the drums, would be (theoretically) but the bare 150 pounds, and *that* upon the furthest in the series from the main drum, exclusive of what is on the main drum.

It now remains to show the effect of the friction which arises from the tension of the belt, and to show the whole amount of power *wasted*, compared with that required to do the work.

The *force* of friction at the rubbing surface may be taken at one-seventh of the pressure. Now the first drum of the series, in the foregoing example, was found to be loaded with a pressure upon the journals of 1050 pounds (exclusive of any effect of the friction caused thereby in adding to the tension of the belt and consequently increasing the pressure) one-seventh of which is 150 pounds at the surface of the journals.

Allow the drum to be ten times the diameter of the journals, and the force of resistance at its periphery will be $\frac{1}{10}$th of the intensity, or 15 pounds $= \frac{1}{70}$th of the *pressure*, the degree in which the stress of the belt must be *increased* to meet the demand of *friction*.

This increased tension of the belt, extends to the main drum, re-acting upon the first only 15 pounds, twice that force, or 30 pounds upon each of the remaining 9 drums over which it passes. The sum of these pressures $30 \times 9 + 15$, $= 285$ pounds the pressure due to the friction of the journals of the first drum.

The pressure found for the second drum, as given in the table 1200, and the above 30 pounds from the friction of the first drum, is 1230 pounds for the actual pressure against the bearings of the second; $\frac{1}{70}$th of this pressure, or 17 $\frac{4}{7}$ths pounds goes to increase still further the tension of the belt beyond this second drum, throwing 17$\frac{4}{7}$ths pounds additional pressure on the bearings on the second, and twice that force upon each of the remaining eight, or, omitting fractions, $35 \times 8 + 17 = 297$ pound pressure due to the friction of the second drum.

Again $\frac{1}{70}$th of the 1435 pounds pressure on the third drum, as the increased tension of the belt, added to the pressure of the third, and twice upon each of the seven remaining drums, gives $40 \times 7 + 20 = 300$ pounds for the friction of the third drum; fourth drum 300; fifth drum 286; sixth drum 261; seventh drum 224; eighth drum 175; ninth drum 114; tenth drum 41 pounds, in whole numbers, as the pressures on these several drums, from these several degrees of friction arising out of their respective proportion of labour and relative position in the series.

The sum of all these pressures is 2226 pounds, which added to the sum of the pressures before set down as due to the proper labour of the several drums, amounting to 19050 gives 21276. If to this we add 1500 pounds, the pressure before given upon the journals of the *main drum*, the amount will be 22776 pounds, as the entire pressure (sufficiently accurate for our purpose) upon all the drums upon the plan and under the conditions specified. Where-

as, upon the plan of having a *separate belt* for every drum, leading from one side of the main drum, allowing 150 pounds for each drum, and the same for each upon the main drum, that is 300 pounds pressure for each of the ten drums, and 64 which is $\frac{1}{7}$th of the whole, on account of the friction arising therefrom, the total of pressure will be 3064 instead of the 22776 pounds, whilst the sum of the tension of all the belts, at the tightest side, will only equal *half the greatest tension of the long belt* employed in the foregoing plan.

The effect of friction, taken at the surface of the drum (where the labour to be performed, was estimated,) say $\frac{1}{10}$th of the pressure, will be, to consume $\frac{308}{1000}$ths as much power, as is required for the proper labour of the mill, in the one case, and only $\frac{44}{1000}$ths in the other case—or as 1 to 7.

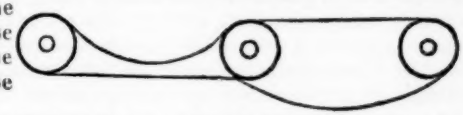
After some appropriate remarks upon the mode of arrangement, which places the line of main drums at one side, instead of in the middle of the room, Mr. Beard gives what he considers the best practicable plan—a plan which, according to my limited knowledge of cotton and woolen mills, appears a very judicious one for accomplishing so desirable an object, as that of the pressure of one belt, counteracting by another, thereby preventing a vast consumption of the power, by unnecessary friction.

A few remarks upon another point advanced by Mr. Beard, will close this notice of the very important subject before us, which I should have been gratified to have seen from an abler hand than mine.

The point alluded to is that of the advantages of placing drums so far asunder, when circumstances will permit,as to give the belt sufficient *length, to cause adhesion to the drum, without too great a tension of the belt.*

"It is," says he, "of great importance, that each belt should be of such a length, that it will adhere to the drum so much as to prevent it from slipping, and that without the necessity of putting on the belt so tight as to cramp the drums and wear the bearings. Every belt, to run easy and well, should be so slack when running, that the slack side would run with a waving undulating motion, *without any tension*, except on the leading side &c."

It will be difficult, I believe, to understand, how a belt can at one time owe its adhesion to its *tension* at both sides of the drum, and at another time, to its *greater length*, between the drums, and *its tension on one side only.* For it should seem that under any circumstance, (except by some adhesive substance interposed to prevent it) a complete relaxation of tension upon one side, would amount to a relaxation of the other, and if the fact be as stated (and I believe it to be pretty generally received as such) I know of no principle upon which to solve the difficulty, unless it can be shown, that when one side is slack, it has a greater bearing surface on the drum, by lapping further round it. That this cannot always be the case, the following cut will show. The cut represents a section of these drums, the middle being the driving one, the belts of course leading off right and left.



It is obvious on inspection, that whilst one of the belts will gain by lapping farther around the drums, the other will loose in that respect.

It appears necessary therefore to seek some other explanation—may it not be owing to the continual flapping of the belt, which increases the tension for the moment in a sort of *twitch*, at each vibration, and that the mo-

mentum of the drum, continues it in motion, during the interval when the tension is of course diminished ?

Admitting this *suggestion* to be correct as far as it goes, still there would be an appreciable difference; it would seem, in the two belts repesented in the cut for the reasons before suggested, besides leaving a considerable portion of the strain and pressure to destroy the belt and wear the bearings. One thing is certain that whether the belt be long or short, one means of securing it from slipping is to make it *shorter.*

There is much justice in the remarks of Mr. B. that sufficient care is seldom taken to have belts to run free and easy, and it has been one of the greatest errors more or less prevalent in all Cotton and Woolen Mills to run the belts so as greatly to injure the belts, and rapidly increase the wear of the bearings—and when belts will so run without slipping upon the drums or pulleys, they will wear for a great length of time. For although a belt may be heavily loaded, yet, if at every revolution it can have an opportunity for relief from its tension, so as to contract to its natural texture, it will prevent it from breaking by the stress upon it?

May not the belt of greater length be more durable, chiefly on account of its being less frequently strained, and bent and straightened in passing round the drums or pulleys?

One word on the subject of high velocities: Mr. B. says "a belt adheres much better and is less liable to slip when it runs at a quick speed, than at a slow speed." I have frequently before heard this thing asserted, and have myself observed something of the kind in a case where the work done was interrupted or irregular.

Not being able at this time to assign any better reason, I attributed it to the greater *momentums* of the moving parts, acting in a degree as a fly wheel. In the case alluded to a rope instead of a belt was used.

Yours, &c.

Physical Science.

Experiments on Solar Light. By John W. Draper, M. D. Professor of Chemistry, Hampden Sidney College, Va.

(Continued from p. 114.)

115. *Effects of light on vegetation.*

115. Botanical authors have long been aware of the important effects which solar radiations exercise over the colour of vegetables. A plant, which grows in the dark, is of a pale whitish colour, and of a transparent aspect, possessing none of that greenness and vigour which is so characteristically developed on exposure to the sun; its consistency is watery, and although its growth may not be stunted, its appearance is very sickly, its secretory actions are not duly performed, and all its vital operations are carried on in a state of force. There is no longer any evolution of nitrogen from the leaves, and consequently no apparent production of oxygen gas. Light, which seems to act merely as a stimulus on the green organs of vegetables, indirectly bringing about the decomposition of carbonic acid, though accessory is not however essential to the growth of plants. Sub-

teranean cavities, and places far removed from the direct solar ray, have a flora of their own; and in the abysses of the ocean, at depths to which no solar beam can penetrate, and where there is a perpetual night, green plants are found flourishing.

116. The green colour of leaves, is presumed to be an immediate consequence of the act of decomposing carbonic acid. (Decandolle phy. des plantes) It appears to me, that there is some obscurity, if not an actual error, in the view which botanists take of this matter. They suppose, that by the stimulus of light, some portion of the green organ is enabled to decompose that gas, *completely*, or to accomplish its actual resolution into an equivalent volume of oxygen, with the entire deposition of the carbon in the solid form; that it is moreover this carbon, so deposited, that gives origin to the green colour, seeing it forms the *chromule verte* itself. Much useless ingenuity has been thrown away by some chemists in explaining, how carbon, the colour of which is black, or a deep Prussian blue, can produce a lively green, and even if their supposing that the modifying action of a yellow tissue spread over it were correct, of which there is much doubt, considering the thinness of that tissue, and the lightness of its tint, yet certainly we have no necessity to resort to any such explanation. The deposit is not carbon chemically, it contains both oxygen and hydrogen in unknown proportions. Of all the physical characteristics of a body, colour is the most inefficient, it is even proverbial, that after uniting in a new mode, compounds never bear the colours of their constituents; nay more, carbon itself is not essentially of a black colour, as the diamond proves.

117. To a deposit of some compound, in which carbon enters as an ingredient, we are to refer the green colour of leaves, but not to carbon itself. On this point, vegetable physiology has been thrown into error by incorrect information, as respects the chemical part of the phenomenon. The earlier chemists, who did not possess those extremely delicate methods of gas analysis, which are now available, gave wrong evidence in this matter. They stated that on exposing a plant to the sunshine, in contact with carbonic acid, the carbon was separated in a concrete state, the oxygen being left—but such is not the fact; by no known laws can such a change be brought about, and hence any reasoning based upon it, as to the colour of plants, is irrelevant. For when a plant exposed to the sun decomposes carbonic acid, a certain volume of oxygen disappears at the same time; in lieu of this, and in obedience to the laws which guide the transit of gases through tissues, (Jour. Frank. Inst. Vol. XVIII., p. 27) an equivalent volume of nitrogen is surrendered by the plant in return. Sometimes it is carbonic oxide which is absorbed, sometimes oxalic acid, or other compound of carbon with less proportion of oxygen. I do not here indicate from whence that nitrogen is derived, since botanists assert, that some plants contain no nitrogen at all; it may however exist in their juices, as gas exists in spring water, or may be retained in a compressed state on their surfaces, it is however a remarkable fact, that nitrogen is present, and perhaps not less remarkable, that its presence has hitherto been entirely overlooked.

118. The carbon thus taken from the acid, does not pass through the tissue of the leaf in a concrete form, or give rise to a concrete deposit; it bears with it a certain part of the oxygen with which it was formerly united, the rest being set free; the carbon and oxygen so conveyed into the plant, entering into combination with hydrogen, gives rise to the chromule verte; hence we see, that the green colour depends indirectly on the de-

composing action, that when this goes on without interruption, that is fully developed.

119. I took five pea plants out of the garden, as nearly resembling each other in size, and other particulars as might be: they had just appeared above the surface of the earth, and were beginning to put out leaves. These plants I designate by the numerals 1, 2, 3, 4, 5. Each one was planted in a small glass vessel, with a hole in the bottom for the purpose of supplying it with water, after the manner of a common flower pot. Number 1 was placed in a box, into which light passed which had traversed a solution of sulphate of copper and ammonia. No. 2, in a similar box into which light was admitted after having undergone the action of chromate of potassa. No. 3 was placed in the open air. No. 4 in a box, into which light passed which had been transmitted through sulphocyanate of iron. No. 5 was shut up in a dark closet. This arrangement was completed on the second day of May. With a pair of compasses the height of each plant was ascertained, and of that, and of the number of leaves, a memorandum was taken. In three days time an examination was made.

No. 1, had attained three times its former height, and doubled its number of leaves.

No. 2, not quite twice its former height, no new leaves, in appearance not so plump and transparent as formerly.

No. 3, twice its former size, with no fresh leaves.

No. 4, four and a half times its former size, and double its number of leaves.

No. 5, three and a half times its former size, the leaves looked yellowish.

120. It is here proper to remark, that the increase of size is not to be taken as an index of any action of the absorbing medium. Some years ago, I had occasion to notice, that rapidity of growth was greatly influenced by the quantity of aqueous gas in the atmosphere. Whether the observation possesses any novelty, I am not prepared to say, but if any one causes plants to grow in glass vessels, containing the maximum quantity of vapour which their atmosphere can hold, at the temperatures under trial, their unusual increase of dimensions, will present a strikingly remarkable phenomenon.

121. In fourteen days, from the commencement of this experiment, another examination was held.

No. 1, all its leaves of a grass green.

No. 2, of a darker green.

No. 3, green, but of a bluish tint when compared with a plant taken from the garden.

No. 4, of a bright green.

No. 5, pale whitish yellow, with no fresh leaves, but grown to thirteen times its former height, and apparently in a vigorous condition.

N. B.—With respect to No. 4, the plant under sulphocyanate of iron, I was not aware at the time of making this trial, of the singular properties of that substance in relation to light; in the course of a fortnight, which had elapsed, the solution from being of a deep blood red, had become perfectly colourless. No reliance is therefore to be placed on this result.

122. Among a number of experiments which were instituted with an intention of illustrating the same point, and which gave analogous results, it may be mentioned that the seeds of common garden cress, were caused to germinate and grow in the boxes mentioned above. And no matter what was the substance through which the light passed, the young plants after

reaching a certain size, were always green,—but those which grew in the dark had yellow leaves and white stalks.

123. The general result of these trials goes to prove, that it is not this or that species of ray, which gives rise to the colour of leaves, the absence of the chemical ray, or of the calorific ray does not appear to affect it, nor have we any direct proof that the colorific ray exercises any influence. Humboldt has stated, that in the mines of Germany, plants as the *poa annua, et compressa, plantago lanceolata*, &c., grow in recesses where the sun's light never comes, and provided hydrogen gas be present, their colour is green. In the Atlantic ocean he saw a marine plant *fucus vitifolius*, brought up from a depth of 190 French feet, where according to the calculations of Bouguer, the light was only equal to that emitted from a candle at 203 feet distance, and yet its colour was green. Decandolle mentions that artificial light, as that of lamps gives the same result; a proof that it is certainly not the chemical and perhaps not the calorific rays which cause the phenomenon.

124. Perhaps light in this case acts only as a kind of stimulus; it would be desirable to make trial of some plants whose leaves are naturally white; of this class there are several individuals; would they or would they not cause the decomposition of carbonic acid? From many indications it is not improbable that there is a variety of chemical rays, each of which brings about changes of a character appropriate to itself. As yet, we have not learned to distinguish these from each other, and are not provided with the means of effecting their separation. A remarkable observation which appears to me to be very much in point, was made many years ago, by Prof. Silliman; it has not obtained that attention which it deserves; he states, that on exposure of a mixture of chlorine and hydrogen to the *light* of a fire, an explosion was produced. I quote the fact, however, only from memory, and have endeavoured to substantiate it under a variety of circumstances, but with a want of success probably due to the absorbing action of the glass jars used, or to the nature of the light. It is desirable that this experiment should be once more repeated; it would settle an important point, that chemical rays of different characters exist. I have referred to this before in speaking of the perehilion motion of matter; for it is more than probable, that there are chemical rays not absorbable by the chromates of potassa.

NOTE.—*In the foregoing papers the reader is requested to make the following corrections of typographical errors.*

ERRATA

Sec.	line	instead of	read.
2	2	coherent	inherent
3	8	same light	sun's light
9	8	prism *a*	prism *d*
19	25	in the practical	in practical
40	8	glasses with	glasses fig. 19 with
40	10	various apertures	narrow apertures
40	16	chemist	chemists
41	1	pressing	falling
41	12	multipule	multiple
43	8	40° Fah.	110 Fah.
45	5	isometric	isomeric
48	3	c + 2O	C + 2O
48	6	c + 6	C + O
50	10	26 + N	2O + N
56	7	least	last
58	3	temperature	temperatures
58	3	moveable	invisible
58	4	moveable	invisible
59	20	laternal	lateral
68	11	Sulphocyrate	sulphocyanate
68	15	Sulphocyrate	sulphocyanate
68	23	platiniuim	platinum
69	24	an analysis	on analysis
71	5	hydrodide	hydriodide
72	2	cloride	chloride
94	15	æquilibris	æquilibrio
99	4	natural	internal
114	1	wherever	whenever

Recent Occultations.

The immersion of Antares behind the moon's dark limb on the 10th of August last, was observed at several places in and near Philadelphia, as

follows, in mean time of the places of observation. At the time of emersion the moon was obscured by clouds,

No.	Observer.	Mean time.	Latitude.	Assumed Longitude.
1	S. Sellers,	10h 17m 47s.20	39° 57′ 5″	0s.00 W. of State House.
2	S. C. Walker,	49 .09	56 54	1 .05 "
3	W. R. Johnson,	42 .79	59	5 .16 "
4	W. H. C. Riggs,	42 .99	59	5 .16 "
5	J. Gummere,	16 44 .00	40 1 12	35 .00 "
6	S. J. Gummere	43 .50	12	35 .00 "

The reductionof these observations after the method of Bessel, Astronomische Nachrichten, No. 151 and 152, has furnished the following results.

No.	m	a	b	c	d
1	— 5h 0m 31s.26	+ 1.747	— 3.087	+ 3.547	
2	31 .41	+ 1.747	— 3.082	+ 3.542	
3&4	35 .38	+ 1.747	— 3.083	+ 3.544	
4&5	1 4 .48	+ 1.747	— 3.030	+ 3.498	— 5h 1m 13s.74

Where,

m = the longitude from Greenwich + East — West, that would be deduced from the observation if the star's and moon's places as given in the Nautical Almanac were free from error.

ε = the number of seconds of arc by which the moon is more or less advanced in its orbit than its tabular place.

ζ = the number of seconds of arc by which the moon is north or south of its tabular place, measured on a perpendicular to its orbit.

η = the correction of the moon's tabular horizontal semi-diameter.

d = the longitude obtained by applying these corrections, whence

$d = m + a\varepsilon + b\zeta + c\eta$; assuming,

d = — 5h 0m 40s for the State House, Philadelphia, the observations give,

— 9.″26 = $a\varepsilon + b\zeta + c\eta$, and for Haverford School

d = — 5h 1m 13s.74, as above.

SEARS C. WALKER.

September 6th, 1837.

Civil Engineering.

A short Historical and Topographical Sketch of the La Grange and Memphis Rail-road, Tennessee. By CHARLES POTTS, Chief Engineer L. & M. R. R.

The La Grange and Memphis Rail-road Company of the State of Tennessee, was incorporated by the Legislature of that State on the 14th of December, 1835. The charter is the first of its kind granted in this State. The capital stock of the company, designed for the main stem of the road, is fixed at 300,000 dollars in shares of 100 dollars each, which may be increased to 500,000 dollars. At the time the company was incorporated several lateral branch roads were contemplated and connected in the bill; the only one, however, which has fulfilled the requisitions of the charter, was the branch road from Moscow to the town of Somerville. To construct this branch the charter allowed an additional sum of 75,000 dollars,

making the entire capital of the company 575,000 dollars. The corporate powers of the company were secured upon the subscription of two thousand shares of said stock. The rights and privileges granted to this company by the several provisions of its charter, are as full and ample as the warmest friends of the measure could have desired; it is, in fact, one of the best Rail-road Charters ever granted, and reflects the highest credit on the skill and ability of those individuals from whom it emanated.

In addition to this special act of the Legislature incorporating this company, a bill of more general character was passed by the same body on the 19th of February, 1836, entitled "An act to encourage Internal Improvements in this State." By this law it is enacted, that in all cases where any joint stock company has been, or may hereafter be incorporated by the Legislature of this State, for the purpose of constructing any work or works of Internal Improvement by means of Rail-roads, or McAdamized turnpike roads, within the limits of the same, and two-thirds of the capital stock of such company or companies shall have been subscribed by individuals; or by other incorporated companies, and in the opinion of the Governor, Comptroller, Treasurer and Secretary of State shall be well secured, it shall be the duty of the Governor to subscribe, on behalf of the State, for the remaining third of such capital stock, &c.

On the first Monday of April, 1836, the books for the subscription of stock were opened according to the requirements of the charter, in the towns of La Grange, Memphis, Somerville, &c., and in the course of ten days the whole amount required was subscribed and taken up, chiefly by the rich and wealthy planters of the counties of Fayette and Shelby. It is a matter of congratulation to the company that none of the stock was allowed to find its way into the hands of jobbers and speculators. A general feeling friendly to the road prevailed in the community from the earliest agitation of the subject, and a strong desire and determination had become established, as was clearly evinced at the time of subscription, that the undertaking should be started upon a basis which should inevitably carry it on to completion.

The preliminary arrangements in reference to the co-operation and league with the State, having been settled by the Commissioners and the Executive, the first election for Directors was held on the first of June, 1836, whereupon General Eastin Morris, Cols. Edward Cress, ——— Jones, Charles Michie, H. S. Morgan, and George Anderson, Esq., on part of the Company, and Majors Robert Lawrence, Epps Moody, and George Wyatt on the part of the State were returned duly elected. Upon the organization of the Board of Directors, General Eastin Morris was made President, John Anderson, Esq. Cashier, and Mr. Adams, Secretary. The following report which was made in the beginning of January 1837, contains an abstract of the operations of the company up to that period.

First Report of the President and Directors of the La Grange and Memphis Rail-road Company.

In compliance with the requisition of the 8th section of the act entitled "an act to incorporate the La Grange and Memphis Rail-road Company," passed December 14th, 1835, the President and Directors have the honor to submit the first Report of their official proceedings, with a detailed statement of the affairs of the company.

Books for the subscription of the stock were opened at La Grange, Memphis, Sommerville and other places on the first Monday of April, 1836, and the capital was subscribed within ten days.

An election was held on the 11th day of June, for nine Directors, and on the 15th the Board was organized and the officers elected. On the same day a resolution was adopted authorizing the President to accept the services of an Engineer and assistants to lay off the road. In obedience thereto Charles Potts, Esquire, of the city of Philadelphia, who had previously been highly recommended to the commissioners, was on the 21st of June notified by mail of his appointment to the office of Chief Engineer to the company; and he was requested to bring with him his assistants, and all the necessary implements, such as levels, transits, compasses, chains, rods, tapes and stationary, so as to be able to commence the surveys immediately on his arrival. On the 2d day of August a letter was received from Col. Potts under date of 13th July, accepting the appointment and informing the Board that he would be on the ground as soon as practicable. The difficulties, however, of procuring the requisite engineering instruments, together with the low water in the Ohio river, prevented the arrival of the corps until the 13th September. A few days thereafter the surveys were commenced, and have been prosecuted with unremitted zeal and perseverence up to the present time.

The surveys were commenced at La Grange, the corps consisting of the Chief Engineer, an assistant engineer, two target bearers, two chainmen, an axeman, wagoner, &c. On the 8th day of October the Engineer reported that he had proceeded in his preliminary surveys as far west as the old Agency or within one and a half miles of Mr. Glenn's, viz: Commencing at La Grange, near the junction of Main and Third streets, thence down Third to the Methodist meeting house, thence a northwestward course towards Mrs. Cage's, and from thence passing through the lands of Moses Frazier, Col. Edward Cress, Peachy Franklin, Mr. Kidd, Mr. Gwin, Rev. Mr. Roberts, Mr. Walker, Mr. Ford, dec'd, Messrs. Shinpoch and Moss; thence through the town of Moscow to Wolf, or *Nashoba* river, below the present road bridge. From this point passing southwestwardly through the swamp, the lands of Jno. A. Frazier, Mr. Avett, Messrs. David and Robert White, Mr. Head, Mr. Stegald, Mr. Burns', Messrs. Parrish and Burns, Mr. Thompson, Mr. Douglass, &c. and along Jernegan's Run.

On the 6th November, the Engineer made his second report, and that he had completed the preliminary surveys. Commencing at the last point of termination, and passing through the lands of Major Robert Glenn, thence along the north edge of the prairie, thence via Miles Davis', Esq., Mr. David Davis', J. Reagan's, Col. Tipton's, Mr. Ware's, Mr. Snow's, &c.; thence across Thomas' Run, to the land of Dr. Smith, thence along the Nonconnah Ridge, the Memphis road, at Collier's, or *New Haven*, thence on the south side of said road, and nearly parallel with it, along the north edge of Dewoody's land, crossing the Memphis road at Parks' old fields; thence continuing on the north of said road to the land of Mr. Baugus, thence continuing on the main ridge via Reddice's, Crain's, and Germantown. Thence on the ridge, leaving the Memphis road on the south, and after running through a mile and a quarter of woodland, nearly due west passes through the lands of Mr. Brooks, thence through the land of Mr. Winford, and crossing the Memphis road through the lands of Mr. Harrison, Hall, &c. thence on the north side of the Memphis road, through Mrs. Marlow's land and in a line nearly parallel with the Memphis road to Dr. Dunn's new field, thence by a line bearing considerably south of west to the southeast corner of Mr. Buntin's land. From thence leaving the ridge, along a division line between Maj. Dunn and the adjoining tracts of land on the

north belonging to Messrs. Buntin and Wyatt, thence through the south-west corner of Wyatt's land and along the line between Bettice and Rozell, to a point due north of Bettice's dwellings, when the line diverges to the north through the middle of Rozell's land and through Carr's out field to the Pidgeon Roost road—thence on the west side of said road and nearly parallel with it to the bayou at Memphis, leaving Dr. Ragland's dwellings and out houses on the north, as also those of Dr. Dunn—striking the bayou at a point of a ravine about twenty rods south of the bridge, thence up the ravine to the landing on the Mississippi river a little south of Walker and Atkinson's warehouse.

The subjoined report marked (A.) contains the alterations, estimates and final location of the road; and to which the stockholders are referred for an able and satisfactory exhibition of the plan and cost of the entire work.

The surveys of the lateral road from Moscow to Sommerville were executed by Franklin Crawford, Esq., the Resident Engineer for that branch. The bearings, cost and estimates of which are clearly and satisfactorily given in his report appended, marked (B.)

And the Board of Directors take this occasion to say they have entire confidence in the experience, skill and ability of the Chief Engineer and his corps of Assistants, and that the surveys have been accurately and faithfully executed.

The preliminary surveys having been completed by the first of November, the next consideration of the Board of Directors was to determine upon the most suitable time for the reception of proposals for grubbing and grading the road, and procuring materials for the superstructure. And here they were met by conflicting difficulties. If they postponed the letting until the present or succeeding month so as to give ample time for foreigners to propose for contracts they would in all probability preclude the stockholders and other citizens, from entering as competitors for the undertaking, which justice and sound policy forbade. Under this view of the subject the Chief Engineer was instructed to advertise for the reception of sealed proposals until the 24th ultimo, for the letting of the whole road; thus enabling the citizens to avail themselves of the opportunity of hiring negroes during the holy-days, and giving quite a sufficient time to extend the notice through the middle and southern States.

On the evening of the 24th December the proposals were opened, and it was found that bids were made for grubbing and grading nearly the whole road, and for furnishing a great portion of the timbers; but generally at prices ranging from 50 to 100 per cent. above what are usually allowed for the execution of similar works, and about the same above the estimates of the Chief Engineer, whose judgment and experience in such matters entitled them to the highest consideration. The average cost for excavation and embankment on the Tuscumbia and Decatur road was 11 cents per cubic yard, and that in a heavy clay soil, with hard pan and rock obstructions; and the grubbing fell short of $170 per mile. With a firm belief therefore, that few if any of the propositions ought, or would be acceded to, their further consideration was postponed for the official action of the new Board of Directors.

If contracts cannot be closed with individuals shortly, at fair prices, it is evident that there is left but one course for the directors to pursue, and that is to purchase negroes, hire hands, employ superintendants, and prosecute the work forthwith, under the direction of the Chief Engineer.

A preferable scheme, however, for a speedy completion of the grubbing and grading is to let it to individuals in small contracts, if it can be economically done. But it is idle to talk about the adoption of either plan unless the most energetic steps are taken to place at the disposal of the directors the requisite funds.

By the 4th section of the charter, not more than one-fourth of the stock can be called for in any one year. And assuming it as certain that the calls will be made as soon as they can legally be, there will be due for the year ending the 15th June next, the sum of $93,750, to wit, $62,500 from individual stockholders, and $31,250 in bonds of the State, payable to the company twenty-five years after date, bearing an interest of $5\frac{1}{4}$ per cent. per annum. Of this sum there has been called only $18,750, to wit, $12,500 from individuals, and $6,250 from the State; leaving $75,000 to be paid in by the 15th June next; $50,000 in cash and $25,000 in State bonds.

Should subsequent calls be regularly made and punctually met, the whole capital stock will not be paid in, if in monthly payments, before the 15th June, 1840, more than a year beyond the time originally allotted for the consummation of the enterprise.

By a reference to the report of the Engineer it will be seen that the estimated cost of the whole road, including sidelings, water stations, buildings, damages for the right of way, salaries of officers, engineers, &c. amounts to $496,381 66, being $121,381 66 more than the original capital. But as the charter provides that if the capital stock shall be found insufficient, the President and Directors may increase the same to $575,000 for the main and lateral road. There would remain then unsold 2000 shares, which may be brought into market at any time; say $133,333 $33\frac{1}{3}$ to be taken by individuals, and $66,666 $66\frac{2}{3}$ by the State.

To avoid the hazard of reducing the present stock below its par value by a public sale of additional shares, it is suggested for the consideration of the stockholders whether a judicious arrangement might not be made with contractors, requiring them to receive one-fifth in stock, say the 20 per cent. proposed to be retained as a security for the performance of their contracts. By the adoption of this plan that amount would be paid to contractors as cash, and the company would receive in bonds from the State, half as much more.

Immediately after the organization of the Board a correspondence was opened with several extensive Iron dealers and shippers in Philadelphia and New Orleans with a view of the procurement of the requisite quantity of railway iron, &c. The proposition of Messrs. A. & G. Ralston of Philadelphia, to import the quantity required at 5 per cent. commission, one per cent. bank commission, and 6d per ton for inspection, and requiring no advancement of funds until the arrival of the iron in this country, being the best received, the President and Chief Engineer, in conformity to instructions, on the 8th day of November last, commissioned the House to procure 1493 tons of railway iron, $2\frac{1}{2}$ by $\frac{5}{8}$ inches, 15 feet in length, flat bars with countersunk holes, 10 tons 4 cwt. of splicing plates, and 816 kegs of spikes (100 lbs. each) to be delivered at New Orleans by the 1st Nov. 1837. A reply was received under date of 25th Nov. last, informing the Board that they would import the rails required provided that some arrangement could be made for the transmission of funds to London along with the order—but that it would not suit any House in America to advance the money for the purchase of that quantity and not be reimbursed for a whole year, particularly when money was worth from two to four per cent. a month. This

disappointment, occasioned by the deranged state of the currency, will require the company to raise by Bills, foreign or domestic, about $130,000 during the present year, over and above the necessary calls to carry on the work.

It will be advisable also, to contract for at least two locomotive engines, and some 40 or 50 cars, to be ready by the time the superstructure is laid. Communications have been received from M. W. Baldwin and William Norris of Philadelphia, two of the most celebrated engine builders in the United States. They each proffer to furnish locomotives, at their manufactories, for $7000 a piece.

Those manufactured by William Norris, for ascending and descending inclined planes, exceed any thing of the kind hitherto attained. The "George Washington," now running on the Columbia and Philadelphia Rail Road, ascended a plane 2800 feet in length, with an ascent in that distance of 196 feet, or at a rate of 369 to the mile, or 7 feet rise in 100 feet, or one foot in 14. The weight of the engine 14,930 lbs. only. The load attached weighed 19,200 pounds, including the weight of 24 persons who were on the tender and burthen car; ascending the 2800 feet in the space of two minutes one second, or at the rate of $15\frac{1}{2}$ miles per hour. Pressure on the boiler under 60 pounds to the square inch. The "Washington County Farmer," another engine built by Mr. Norris, is now in successful operation on said road. The first load drawn by her consisted of 28 loaded cars weighing $141\frac{3}{4}$ tons. The ascents very heavy; the least being 28 feet rise per mile, the majority 32, and the greatest 47 feet. Thus encumbered she passed over the steep ascent of 47 feet per mile, which is upwards of $\frac{3}{4}$ of a mile long at the rate of 22 miles per hour!

It must be gratifying to the Stockholders to perceive by the reasonable estimates of the Chief Engineer, that the annual proceeds of the road when completed will amount to about $109,500, being upwards of 20 per cent. on the entire cost. Should this calculation be correctly based, and it unquestionably is, the stock bids fair to be the best of the kind in America. For that our road will form a link in a great chain of railways extending from Memphis to Charleston does not admit of a reasonable doubt. Every recent movement in the States of South Carolina, Georgia, Alabama and Mississippi, for the accomplishment of this grand design indicates the most favorable result. Governor McDuffie in his message to the South Carolina Legislature on the 29th of November last, strongly recommends that the Charleston and Cincinnati Rail-road should terminate at the mouth of Nolechuchy in East Tennessee. In fact it is difficult to conceive what could originally have induced the citizens of that State to select Cincinnati as a point of termination, when the avowed object of the enterprise was to obtain the entire trade of the west. Why not bring the road directly to Memphis, below the mouths of all the principal branches of the Mississippi river and thus secure the whole, instead of a small portion, of the vast commerce of the Valley?

A rail-road convention, consisting of 107 delegates, representing 38 counties, was held at Macon in Georgia, on the first Monday of November last, comprising many individuals of the first talents in the State. Mr. Chappell, as chairman of a select committee of 40, reported a preamble and resolutions recommending to the Legislature of Georgia to commence a system of rail-road improvements by constructing a rail-road from a point on the Tennessee line at or near Rossville to some suitable point at or near Chattahoochie river, running through the Cherokee counties, on the most practicable route

between said points, hereafter to be ascertained by Legislative provisions. And to authorize any companies that may have charters, and to create others where they do not exist, to branch from any point on said main trunk to the towns of *Forsyth, Athens, Columbia,* and such other places as the Legislature may designate. The State to build the main stem and take one-fourth of the stock in all the branches. The preamble and resolutions were adopted with but two dissenting voices. This may be considered as decisive as to the course that Georgia will pursue in reference to this subject.

It is contemplated that the main stem leading eastward, from Ross' Ferry to Chattahoochie will be about 110 miles in length, and the three branches will vary from 100, 150 to 160 miles.

From the proposed intersection at Ross' Ferry the Tennessee river is navigable at all seasons of the year for the largest steamboats to Decatur, Alabama; and thence to Tuscumbia, 43 miles, a rail-road is in successful operation. From Tuscumbia to La Grange, Tennessee, it is about 105 miles, twenty miles of which are in Alabama, 70 in Mississippi, and fifteen in Tennessee.

About five miles of the proposed Georgia road will fall in this State, but it is designed to effect an arrangement with the Hiwassee Rail-road Company, chartered by our Legislature at its last regular session. This road is to extend from Knoxville to a point in Georgia that will intersect the contemplated road from Memphis to Augusta via Athens. The stock is all taken, and John C. Trautwine, Esq. an experienced Engineer from Pennsylvania, is about to commence the preliminary surveys.

In addition to the prospects of a connection with Charleston, it should be recollected that the Legislature of this State, at the last special session appropriated $15,000 for the survey of a route from the most eligible point on the Mississippi river, as near the centre of the State as practicable, and to run east to the Tennessee river; and from thence for a McAdamized turnpike and rail-road, the most eligible route near the centre of the State, to terminate on the Virginia line, and that there is a reasonable probability that it will join our road at Sommerville.

But should these embryo schemes prove abortive, it is certain that *our road* can, with ordinary exertions, be speedily accomplished, and when completed that it will be sufficiently profitable to satisfy any reasonable stockholder.

In fine, nothing but the demon of discord, petty jealousies, and those party dissentions which will occasionally creep into the best regulated associations, can destroy public confidence, or prevent the company from carrying the enterprise to a glorious and triumphant termination.

The receipts and disbursemehts of the treasury, the amount of cash on hand, and the real and personal property belonging to the company, will be found in the Cashier's exhibit, marked (C.) Respectfully

EASTIN MORRIS,

President of the La Grange and Memphis Rail-road Company.

La Grange, Ten. Jan. 2d, 1837.

At the annual election for Directors which took place on the first Monday in January of the present year, some changes were made in the Directors.—The present Board is composed of the following members viz: Cols. Chas. Michie, President, John J. Potts, Cashier and Secretary; Majors John D. White, John C. Cooper, J. Putney, Elisha W. Harris and Harrison Locke, Directors, on the part of the Individual Stockholders, and Majors Epps Moody, George Wyatt and Robert J. Mahaffy, on the part of the State.—

In the early part of February, the whole of the work required to grade the road,with the exception of twenty miles, was let out to contractors upon very reasonable terms, ten miles of the above twenty have since been let. On the first of July last, over twenty-five miles of the road was grubbed and cleared, and several miles of the road graded. The contractors for grading were delayed considerably for the want of hands and the proper implements to carry on the work ; these difficulties, however, are rapidly subsiding; the partial failure of the cotton crops in some sections of this and the adjoining State, has caused hands to be more plenty, whilst the demand for carts, barrows &c. required on the road, has induced mechanics, to locate themselves in the vicinity of this improvement, and to enter more largely into this species of manufacture.

The survey of this road, as now permanently established, begins at the town of La Grange, and from thence runs westwardly persuing the dividing ridge between the waters of North and South Forks of the Neshoba or Wolf River, crossing the latter near their confluence at Moscow. From this point the road runs nearly straight and level along the bottoms of Wolf River, about ten miles, when it strikes a spur of the Nonconna Ridge,which it rises, and thence pursues the summit of said ridge to the Mississippi River at Memphis. The whole length is nearly fifty miles. The profile of the ground is rather undulating, the fall from the town of La Grange to Wolf river is 225 feet; from this point to the Bluffs at Memphis the fall is 82 feet, and from the Bluffs to low water mark of the Mississippi river, the fall is 50 feet, making the entire descent from La Grange to the Mississippi river 357 feet. The lateral branch road which commences at Moscow, and extends to the town of Somerville, is thirteen and one half miles long. As far as it has been practicable the road has been located in a straight line, very few curves are made, the smallest being 1260 feet radius. Many of the tangent or straight lines are five mile in length—the one on Wolf river bottoms is nearly ten miles long. In profile, the road is undulating—the heaviest grades, however, which occur between La Grange and Wolf river, and in rising the Nonconna ridge, are only 40 feet per mile. The recent improvements that have been made in the arrangement of Locomotive Engines, make grades of this magnitude easy of ascent. On the Columbia road in Pennsylvania, many of the inclined planes are 40 feet per mile, and some of them 47 feet—the improved engines on this road carry the loaded trains over these grades with very little change in the velocity.

The ground over which the road runs is generally sandy loam, the larger proportion being sand ; the country is entirely an alluvial formation; on the bottoms of Wolf river a slight mixture of clay obtains; no solid rock of any magnitude has as yet been discovered; on the branches of some of the streams running into north fork, and along which the lateral road passes, some traces of sand rock have been obtained, and applied to the cosntruction of drains on that part of the work ; gravel is also scarce, and seldom occurs near the surface, or at such depths as it will be required to cut in most of the excavations along the road. The company is allowed by their charter to condemn 200 feet in width of ground for the use of the road. The superstructure is to be formed with timber; the first ten or fifteen miles next to Memphis will be laid with cedar; a portion of the timber for this part of the road is now under contract—the mud, or foundation, sills, are to be 3 by 9 inches—the cross-ties 8 feet long, hewn flat on one side, and to square 6 inches in the heart of the stick; to be laid down 3 feet apart from centre to centre. The string pieces, or rails, are to be 5 by 7 inches, champhered

and faced with the flat bar iron $2\frac{1}{4}$ by $\frac{1}{8}$ inches; these bars to be fastened on the rails with 5 and 7 inch spikes; those 7 inches long are intended for the ends of the bars. The cost of a single track of the superstructure, laid as above, is estimated to be $4000 per mile. Bent, or trussel, bridges, will be used to carry the road over the smallest streams and ravines. A model has already been prepared for the Lattice Bridge over Wolf river, and arrangements will shortly be made to put it under contract. Culverts and drains of stone, brick and timber, will be made according to the facilities of getting either of these materials at the site required. Excellent white, and post oak, timber is found either on, or in the immediate vicinity of the whole line of the survey. Since this road has been commenced, several other similar projects have been contemplated to connect with it. A lateral branch from Salem in Tippah county, and another from Holly-Springs, Marshall county, both in Mississippi, are in agitation. The former of these branches it is confidently believed will shortly be put under construction—this branch will probably form part of the connecting link between La Grange and Tuscumbia in Alabama, and a part of the great chain of rail roads connecting Memphis on the Mississippi, with Charleston on the Atlantic. A branch road is also intended from the lower end, and designed to strike the Mississippi river near the old scite of Fort Pickering. At this point a new town has been laid out by John C. McLamore, Esq., to be called the "City of Girard." The site selected for this town, is unquestionably one of the best and most advantageous on the Mississippi river—it is situated on the summit of the Chickasaw-Bluff, and lies about midway between the waters of Wolf river and Nonconnoch. The general surface of the bluff, parallel with the river, and for a considerable extent eastward, is nearly level, and very moderately undulating. Being elevated considerably above the Mississippi river, and having no low grounds either in its front or in its rear, subject to inundations from the river, or the "Bayou Gayoso" the situation is therefore considered both pleasant and healthy. At the foot of the bluff, and along the margin of the river, a bench, or bank, extends for a considerable distance, forming the western boundary of the proposed town. This bank averages 150 feet in width, and is elevated about two feet above high water mark of the river. The bank is accessible in all stages of the water for Steam Boats, and river craft, and therefore affords the most desirable location for large mercantile houses. Memphis, which is situated a short distance above, is a place of considerable business; it is estimated that from this point and Randolph together, over sixty thousand bales of cotton are annually exported to New Orleans. This cotton is entirely the product of four or five of the most south western counties in the district of Tennessee, and the more northern counties in the state of Mississippi. The western district of Tennessee, ten years ago, was in the tenure of the Indians, and it is scarcely five years since any thing like an opening was made in it for the culture of cotton. The northern counties in Mississippi are just passing into the hands of the Planters; the Chickasaw Indians who have hitherto occupied these lands, having commenced their emigrating march in the early part of last summer. The stream of emigration which is pouring into this new country from the States of Virginia, the Carolinas, and Georgia, is beyond conception. The Chickasaw-bluff referred to above, is the only feasible point on the Mississippi river, north of Vicksburg, whereby the products of these counties can be conveyed to the river; this fact together with the fertility of the soil, and congeniality of

the climate for the cultivation of cotton, with the other advantages above related, must all conduce to form at this point, one of the largest and most thriving towns on the Mississippi river.

Bibliographical Notice.

Principles of Geology; being an Inquiry how far the former changes of the earth's surface are referable to causes now in operation. By CHARLES LYELL, Esq. F. R. S. *President of the Geological Society of London. In* two volumes. First American from the Fifth and last London edition. Kay & Brother, Philadelphia, and J. J. Kay & Co. Pittsburg, 1837.

It is seldom that American publishers have done a better service to science than by this republication of Lyell's Geology. Coming to us with all the freshness of a new edition recently from the hands of the author, and with many valuable additions and new graphic illustrations, it cannot fail to render this new and captivating department of knowledge, additionally popular in the Seminaries and among the reading classes of this country. There is no work extant which can come in competition with it; for however meritorious and deservedly popular are the works of Bakewell and Buckland, the subject of Geology is treated by Lyell in a way and mode so distinct from these and other authors, they are scarcely susceptible of comparison. The plan pursued by the latter is so strictly that of induction (the true philosophic method of teaching whenever the subject admits of it) the reader finds no difficulty in confining his attention to the pages before him—his imagination as well as his judgment is brought into play, and he is carried from chapter to chapter by an exhibition of facts of the most interesting character, and by the allurements of a style which is at once a demonstration of a refined and classic taste, and of an understanding thoroughly impressed with the dignity and importance of its theme.

If any one should suppose that this treatise on Geology consists of a detail of formations, and their relative ages; of the order of superpositions, and the various organic remains embedded in their strata,—of the changes produced by violent catastrophes whether of flood or fire,—of the subjects which are requisite merely to convey a knowledge of geological structure,—he will form a most inadequate conception of it, either as a body of facts or a system of profound logical reasoning. It required the energies of a mind, capable of embracing, and trained to the study of, a most extensive circle of scientific and general knowledge, to grapple with the difficulties which the author had to encounter in support of his theory; and we are no less gratified with the mass of information which he brings before us, than with the good taste and judgment employed in his reasonings upon them.

We are so accustomed to consider all the great changes which the earth has undergone; the conversion of continents into oceans the elevation of high mountains above the flood of waters beneath which they had been long submerged,—the existence of extensive lakes where there are now fertile regions and populous States,—and the entire destruction of whole

races of animals, some of which were of the greatest dimensions, as the work of sudden and miraculous cataclysms, affecting the whole sublunary system—we are at first astonished at the proposition, that all these great changes, and a vast multitude of subordinate ones, may have been the result of causes now in operation, and that the changes which are going on before our eyes, may eventually produce alterations of the earth's surface as remarkable as those which Geology and Natural History have ever brought to light. However startling such a proposition may be, and opposed to all our pre-existing ideas of the history of the earth and of man, there is nothing in it so revolting to the imagination, as to prevent us from listening with philosophic interest to the evidence and reasoning of our author. We discover that his hypothesis is advanced with the modesty of true science. We perceive that it bears no sort of relation to the visionary theories, for which the early history of Geology is so distinguished. The facts which he adduces deeply interest us as veritable histories of the past and the present. We discover nothing unreasonable in the opinion, that the whole valley of the Mississippi, as far up as the mouth of the Ohio, may have been formerly a great estuary which has been filled up by the materials constantly brought down by the rivers. These it is known are now accumulating in such amazing quantities as to have produced immense accessions of land even within the memory of persons now living. We are struck with the apparent justness of the conclusion (not however original with our author) that the falls of Niagara were once at Queens-town, that the mighty trough, 7 miles in length, which now constitutes the river below, may have been excavated by the constant erosion of the cataract, and that if the barrier which confines lake Erie, should thus eventually be broken away, and the waters of that and all the upper lakes be thus let loose, the State of New York and a large part of the eastern portion of our continent, might be devastated, and sunk beneath the floods. The author does not advance this as a *probable* occurrence. Lake Erie may be filled up by depositions of transported matter long ere its rocky boundaries are thus invaded, and its wide expanse be changed into fertile prairies and arable fields, with a wide and rapid river extending through them.

It is the constant tendency of rains and floods to wear down the mountains and hills, to transport their masses to the sea, and consequently to effect essential changes in the bottom of the ocean, causing continual accessions of land in places where these depositions remain long undisturbed. Oceanic currents and storms are constantly varying these relations of land and water. Subterranean fire is also a powerful element in the daily local transmutations of the earth's surface. The body of facts, in relation to all these changes, which are embraced within the brief period of authentic history, has been so skillfully arranged in the work before us, no one can read the second book which treats of these facts, without admiting the extreme plausibiiity of the inferences which the author draws from them. These admissions, it is true, must be granted, at the expense of our former opinions with regard to the age of the world. But the facts which have been recently so well established, and which are constantly accumulating, in relation to the changes that have taken place in the organic world, the destruction of species, the entombing of lost and also of existing species, both of marine and land animals, in solid strata of very ancient date, compel us to believe that the registry of the first chapter of Genesis may not have been clearly understood, and that there is a mode of interpretation

which justifies us in our adherence both to the security and truth of the Bible and to the undeniable archieves of Geology.

In his third book the author treats of the changes in the organic world, including the geographical distribution of species, the modifications in physical geography caused by plants, inferior animals, and man; of fossil formations, of coral reefs and other matters pertaining to this new and highly curious and interesting portion of modern Geology; and in the fourth and last book, under twenty-seven distinct heads or chapters, we have a lucid account of the general arrangement of the materials of the Earth's crust. In this division of his work, the genius and industry of the author are particularly apparent. It would have been impracticable, without devoting years to travel and observation, and without an extensive acquaintance with Botanical, Zoological and Astronomical science, to furnish such a theory of structure and change, as he has here exhibited. It was in view of the peculiar merits of this part of Mr. Lyell's work, as well as in reference to its ability as a whole, that the Royal Society of London, awarded to him the Royal medal in 1834. The following were the grounds on which this distinction was confered.

"*First*, The comprehensive view which the author has taken of his subject, and the philosophical spirit and dignity with which he has treated it.

"*Secondly*, The important service he has rendered to science, by specially directing the attention of Geologists to effects produced by existing causes.

"*Thirdly*, His admirable description of many tertiary deposites; several of these descriptions being drawn from original observations.

"*And Lastly*, The new mode of investigating tertiary deposites which his labours have greatly contributed to introduce; namely, that of determining the relative proportions of extinct and still existing species, with a view to discover the relative "ages of distant and unconnected tertiary deposites."

We have omitted to say that in the First Book, after an appropriate statement of the objects and nature of Geology, the author has given a Historical sketch of its progress, in which the reader will find a succinct but satisfactory account, of the fanciful theories and ingenious cosmogonies of Buffon, Burnet, Woodward, and others, as well as of the more philosophic views of Werner, Hutton, and those of their school.

It would be almost superfluous to say that we regard the work before us as one of the most able contributions to human science, which has appeared within the present century; and that it cannot fail, in addition to the labours of others, to place Geology among the most dignified and interesting departments of general knowledge.

But,—in thus venturing to add our humble tribute to the eulogy of others, we would not be understood as expressing our opinion on the sufficiency and perfect soundness of the author's theory. Some lingering doubts, we must acknowledge, adhere to our minds of the entire adequacy of "causes now in operation, to produce all the former changes" which the earth's surface has undergone. But the candour of the author is no where more manifest, than in the putting forth of his theory, and none we presume would be more indulgent to the scruples of others.

Suggestions for the use of the Blowpipe by working Miners. By John Prideaux, Esq

Continued from p. 166.*

When a metallic bead is produced, it may be pure silver, tin, lead, bismuth, copper, gold; or iron, copper, nickel, or cobalt, alloyed with arsenic; or a mixture of various metals.

Gold and silver may be distinguished by not losing their brilliancy in the outer flame; tin by its whiteness and softness; lead and copper are immediately distinguished by their colour; and bismuth by fuming and evaporating in the reducing flame. The arsenical alloys and compounds, not clearly distinguishable by these means, nor by their streak upon the black flint, must be examined by fluxing with borax.

If it give green on pipe-clay, it is copper, though it happen to be bleached by the arsenic.

If blue, it is cobalt.

If orange-yellow while hot, and the colour fly on cooling, it is iron or nickel; and these are distinguished by the reducing flame on charcoal, where the borax bead is bottle-green with iron, but almost colourless with nickel.

If the metal yield no bead, but pass off in vapour, it is quicksilver, arsenic, antimony, bismuth; or, possibly, tellurium, cadmium, or zinc.

If the vapour smell strongly of garlic, it is arsenic.

If it leave a circular halo on the charcoal, it is antimony, tellurium, bismuth, or cadmium.

If the halo be white, it is antimony.

If orange-yellow, it is to be subjected to the reducing flame. If it disappear easily, tinging the flame green, it is tellurium.

If it evaporate with difficulty, and without tinging the flame, it is bismuth.

If it be red, or orange-red, it is cadmium.

If the mineral evaporate readily with no odour, or only that of sulphur, and without leaving a white or yellow halo, it probably contains quicksilver; which is proved, if, on mixing a portion of it with soda and iron filings, heating it on charcoal, and holding a bit of gold coin on the vapour, the quicksilver will show itself on the coin.

If, using soda with the reducing flame, the assay burn, after a while, with a pale-green flame and white smoke, covering the charcoal with a white flaky powder, it contains zinc.

If it will neither yield a bead of metal nor volatilize, but attract the magnetic needle after the operation of the reducing flame, it most probably contains iron; but it may be nickel or cobalt: easily distinguished by fluxing with borax.

If the mineral, or the residue, after part has evaporated, will neither yield a bead, volatilize, nor attract the magnetic needle, we have then to flux it with borax; and the following table will show what it contains:—

* Erratum. At page 161 third line from bottom for Paideaux, read Prideaux.

If it stain the borax: In the reducing flame, on charcoal.	In the calcining flame, on pipe-clay.	The metal is	Estimation.
Blue	Blue	Cobalt	Valuable, for Colouring glass, &c.
Bright green	Colourless	Chrome	Ditto, and for Paints.
Colourless, or reddish	Bluish green	Copper	Valuable.
Bottle-green	Orange, while hot; Bleaches in cooling.	Iron	Of no value unless near coal.
Pale	As iron	Nickel	Valuable.
Dirty green	Yellow	Uranium	Not used.
Purple	Colourless	Titanium	Ditto.
Colourless	Purple	Manganese	Valuable, for bleaching, &c.

Copper is reduced to the metallic state, in the reducing flame; and hence, when in quantity, shows itself in its usual red colour, in the bead.

In mixtures of metals, the indications are sometimes ready enough. If on pipe-clay, we find the borax tinged between orange and purple while hot, and becoming purple on cooling, whilst it gives a bottle-green on charcoal, we immediately perceive the indications of iron and manganese; a very common mixture.

If again, we find it bright green on pipe clay, and emerald-green on charcoal, a mixture of chrome and copper is indicated.

But it more frequently happens that mixtures of metals give ambiguous results; and that they can only be ascertained by caution and perseverance.

Although most of this is sufficiently easy, it requires a little practice: and, to give the operator confidence in his results, this is best performed upon substances which he knows to contain the metals he assays for. Thus, if he operate on common mundic, he is certain, after a sufficient time of roasting and heating on charcoal, to obtain a residuum capable of affecting the magnetic needle. White mundic will leave the same residue, after giving off an arsenical smoke. Green copper (malachite) will be sure to yield a bead of copper on charcoal, and will as certainly produce a fine green with borax on pipe-clay. Any of the ores of lead may be promptly reduced to a metallic bead on charcoal.

The vapour of antimony may be easily distinguished from that of arsenic by the garlic odour of the latter.

A minute particle of manganese will tinge borax a fine purple, on pipe-clay, in the outer flame; but on charcoal, in the blue flame, a much larger portion, dissolved in borax, will become limpid and colourless. A particle of titanium ore will give an opposite result, bleaching on the pipe-clay, and becoming purple on the charcoal.

The experimenter should also not fail to reduce tin ore by the aid of soda, and some ore of zinc by the same means, that he may become acquainted with the appearances in these assays.

Thus varying his practice as materials happen to fall in his way, he will quickly acquire familiarity with the appearances and results, and feel confidence in any assay he may undertake.

Should he wish to carry his investigation farther, and ascertain the pro-

portion of metal contained in the ore, this may be done on a small fragment of any thing which yields a regulus; and by an instrument so simple that a clever workman may make it for himself.

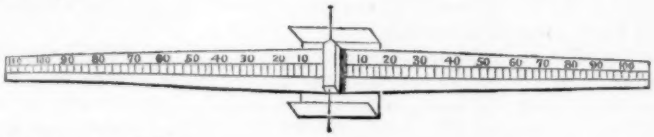
The common marsh-reed, growing in such places, generally, throughout the Kingdom, will yield straight joints, from eight to twelve, or more, inches long. An eight-inch joint will serve, but the longer the better. This joint is to be split down its whole length, so as form a trough, say a quarter of an inch wide in the middle, narrowed away to $\frac{1}{8}$ of an inch at the ends. A narrow slip of writing-paper, the thinner the better (bank-post is very convenient for the purpose,) and as long as the reed trough, is to be stuck, with common paste, on the face of a carpenter's rule, or, in preference, that of an exciseman, as the inches are divided into tenths instead of eighths; in either case observing that the divisions of the inch on the rule be left uncovered by the paper. When it is dry, lines must be drawn the whole length of it, $\frac{1}{8}$ of an inch apart, to mark out a stripe $\frac{1}{8}$ of an inch wide. Upon this stripe the divisions of the inch are to be ruled off, by means of a small square.

The centre division being marked O, it is to be numbered at every fourth line, to the ends. Thus the fourth from the centre on each side will be 10; the 8th, 20; the 12th, 30; the 16th, 40, &c.; and a slip of 10 inches long, graduated into 10ths of an inch, will have on each arm 50 lines, or 125 degrees, divided by these lines into quarters. While the lines and numbers are drying, *the exact centre* of the reed-trough may be ascertained, and marked *right* across by spots on the two edges. A line of gum-water, full $\frac{1}{8}$ of an inch wide, is then laid, with a camel's-hair pencil, along the hollow; and the paper being stripped from the rule (which it leaves easily,) the graduated stripe is cut out with scissors, and laid in the trough, with the line O exactly in the centre. Being pressed close to the gummed reed, by passing the round end of a quill along it, it graduates the trough from the centre to each end. This graduation is very true, if well managed, as the paper does not stretch with the gum-water, after being laid on the rule with paste.

A very fine needle is next to be procured (those called *bead*-needles are the finest,) and passed through a slip of cork, the width of the centre of the trough, about $\frac{1}{4}$ of an inch square, and $\frac{1}{8}$ thick. It should be passed through with care, so as to be quite straight. The cork should then be cut, until one edge of it fits into the trough; so that the needle shall bear on the edges, exactly in the spots that marked the centre, as it is of importance that the needle and trough be exactly at right angles to each other. The cork is now to be fixed in its place with gum-water, and, when fast dry, to be soldered down on each side with a small portion of any soft resinous cement, on the point of a wire or knitting-needle. A little cement being also applied in the same manner to the edges of the cork where the needle goes through, to give it firmness, the beam is finished. It may be balanced by paring the edges on the heaviest side; but accurate adjustment is needless, as it is subject to vary with the dampness or dryness of the air.

The support on which it plays, is a bit of tin plate (or, in preference, brass plate) $1\frac{3}{8}$ inch long and 1 inch wide. The two ends are turned up square $\frac{3}{8}$ inch, giving a base of $\frac{5}{8}$ inch wide, and two upright sides $\frac{3}{8}$ high. The upper edges are then rubbed down smooth and square upon a Turkey stone, letting both edges bear on the stone together, that they may exactly correspond. For use, the beam is placed evenly in the support, with the needle resting across the edges. Being brought to an exact balance by a

bit of writing paper or any other substance placed on the lighter side, and moved toward the end until the equilibrium is produced; it will turn with extreme delicacy, a bit of horse-hair $\frac{1}{8}$ inch long being sufficient to bring it down freely.



This is used as follows.

A suitable fragment for an assay of the mineral to be tried is placed on one side of the beam, and counterpoised by a small weight, or any other substance, on the other side: on No. 100, if the produce be required per cent. (but if per cwt., on the line beyond No. 110;) the assay piece being moved to or from the centre, until the balance is adjusted. Its exact place on the beam being then noted, it is to be taken off and reduced in the usual manner.

When the reduction is complete and the particles of metal have been brought together into one bead, it is allowed to cool, and, being broken out of the soda (if any was used,) is replaced on the beam precisely where it stood before.

The counterpoise will now require to be moved toward the centre, in proportion to the loss of the assay. The number on which it stands, when the balance is restored being multiplied by 10, will give the produce per cent. or per cwt., according to the first position of the counterpoise.

A beam of this kind is described in the "Annals of Philosophy," of a graduated thin slip of deal, the needle fixed on with sealing-wax; but this is rather troublesome to graduate, the polish of the needle is apt to be impaired by the heat; its greater weight also interferes with its delicacy, and a blowpipe bead is very subject to fall off its flat surface. On these accounts, I find the reed beam an improvement. Brass plate is, however, where procurable, preferable to tin plate for the supports: and still much better, two straight bits of fine glass rod or tube, fixed with cement on the edges of a groove, in a piece of wood of the requisite dimensions.

The utility of the information contained in this article, both to the miner and the student in mineralogy, induces us to add a few remarks on the same subject, in order that it may be complete in the present number.

Trusting that our endeavours to facilitate the rudiments of this interesting study, will meet the indulgence and assistance of our more scientific readers, we shall proceed to observe, that as the lamp described by Berzelius, or one of a similar kind, may be almost as easily procured as the miner's candle, it will be found of some importance to employ it in preference, in all cases where it is attainable. It is necessary that the operator should perceive distinctly the conical flame and transparent vapour emanating from the blast; and this desideratum will be effected with much more convenience by using a lamp.

The wick should be cut obliquely, the most elevated part being on the right hand; a longitudinal opening being made for the insertion of the blow-

pipe; care must be taken to use oil which has not been purified by sulphuric acid, for the reason that the acid will always remain in sufficient quantity to effect the texture of the wick, and change the colour of the vapour produced. The cotton should also be in its raw state, or a similar effect may be produced by the presence of the chloruret of lime, which is sometimes used in the process of bleaching.

Until the flame can be well and readily distinguished by the operator, a darkened room will be the best adapted for his experiments; he will soon observe that, when the assay is brought in contact with the interior flame, the surrounding vapour will change its colour from blue to an orange-yellow, the intensity of which will depend on the nature of the substance submitted to the action of the flame. This vapour gradually diminishes and disappears, and the assay becomes surrounded by an atmosphere of a scarcely visible blue tinge, or takes a colour peculiar to the assay which is volatilized at this period of the process.

The carbonate and sulphate of strontian give, at first, a pale vapour, which is succeeded by a most brilliant and permanent red. The same colour is also produced from fluor spar, more intense, but of less brilliancy, and a weaker tinge is given out from the sulphate of lime; arsenic colours the outward flame of a clear blue; antimony somewhat deeper; and lead, a fine azure; green is evolved from boracic acid; minerals containing barytes communicate a paler tinge, but the colour does not become apparent until the assay begins to melt, after which, it increases in brightness and beauty for a considerable time; borax has, at first, a dense reddish atmosphere, and does not exhibit the green colour unless sprinkled with sulphuric acid; minerals containing copper, even in very small quantity, produce a fine green at the extremity of the blue jet; lead ores, holding copper in combination, have a similar appearance, the jet being in this case of a finer blue. The presence of potassium is discovered by fusing a portion of oxide of nickel with borax, and submitting the compound, in conjunction with the assay, to the action of the flame; if it contain potassium, a mass of blue glass will be the product.

These and the preceding indications will be a sufficient guide to the student in very many cases, and his own observations on the process during the experiments will enable him to pursue his study with pleasure, and, possibly, with profit.

Mining Review.

English Patents.

Specification of the patent granted to Thomas Routledge, *and* Elijah Galloway, *of the City of London, for Improvements in Cabriolets and Omnibuses.*—Sealed December 19, 1836.

Figs. 1, 2, 3, 4 exhibit our improvements in omnibuses. The body instead of having straight and parallel seats with an entrance behind is divided into two equal parts, *a*, *b*. The passengers, therefore enter, at either side into the space, *c*, and through the doorways, *o*, *o*, sitting on the circular seats, *d*, *d*, *d*, *d*, as will be clearly seen by the sectional plan, fig. 5, and which, therefore, it is unnecessary more minutely to describe. The wheels are all of equal size, and in turning the carriage they all lock; thus differing from other four-wheel carriages, the fore-wheels only of which can lock.

The mode in which this improvement is effected may be thus explained, *e*, *e*, are two springs on the top of each body, which springs have a hole

through the centre, or are fitted with a socket secured to them by a clip or other well known means, turn freely on the pivots, *f*, *f*, which pivots are securely fixed on the top of the bodies, *a*, *b*; the ends of these springs are also securely attached to the vertical bars, *g*, *g*, to which vertical bars are welded or otherwise securely affixed, the arms, *h*, *h*, upon which the wheels revolve; underneath the carriage there are also springs, *i*, *i*, of corresponding dimensions with those above the carriage, viz., *e*, *e*. The two springs, *e*, *i*, and the vertical bars, *g*, *g*, form together the parallelogram, *g*, *e*, *f*, *g*, *i*, *h*, fig. 2, which turning on the pivots, *f* and *j*, can be made partially to revolve round the imaginary axis, dotted red in fig. 2; and of course with the parallelogram; the wheels upon the arms, *h*, *h*, will also move round the said imaginary axis. Now turning to the diagram, fig. 4, which represents a plan of the omnibus as if it were turned upside down, there will be seen a connecting-rod, *k*, attached to pins on the springs, *i*, *i*, there being holes in the connecting-rod ends so that it may move more freely on them. If, then, the parallelogram and wheels No. 1, (fig. 4) be moved into the position of the blue dotted lines, then the parallelogram No. 2, would be also moved on to the position of the blue lines, there shewn, and, therefore, the wheels would assume the position there shown by the blue lines; or if the parallelogram, No. 1, be moved in the opposite direction, into the position of the red lines, all the parts would assume the positions shown in red lines. The pole is attached to the frame, *l*, *l*.

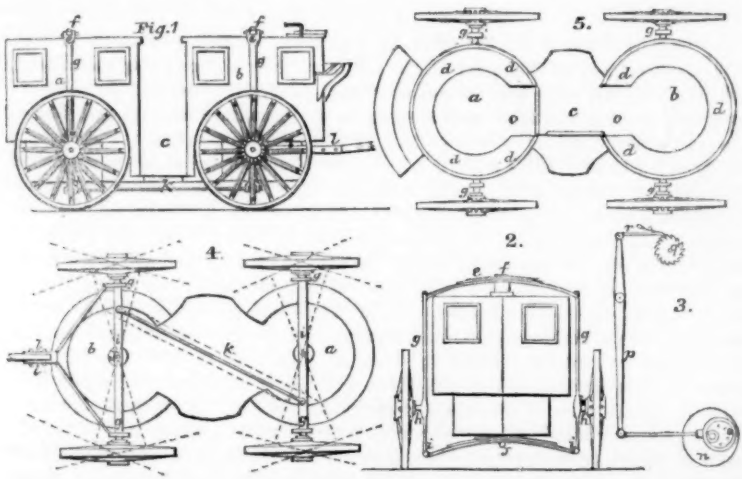


Fig. 3, is a diagram which explains the principle of our indicator for ascertaining the distance traveled by a cabriolet or omnibus. *n*, is the nave of the wheel to which the eccentric, *o*, is affixed on the end nearest the carriage; it will be readily understood that each revolution of the wheel communicates a reciprocating motion to the lever, *p*, which again gives motion to the pall, *r*, which pall moves the ratchet-wheel, *q*, one tooth for each revolution of the wheel. This ratchet is fixed to some part of the body of the carriage, and communicates its motion to a train of wheel-work well known in similar instruments, and which causes a hand or pointer to record the number of revolutions made by the wheel; and the diameter of the

wheel being known, the index can be graduated so as to show the distance (in miles, yards, or other known distances) which the carriage moves over.

And, lastly, in order that we may be clearly understood as to what constitutes our improvements in cabriolets and omnibuses, we hereby declare that we lay no claim to the invention of such parts of the cabriolets as have been previously used and are well known: but we claim in them an improved combination of parts, some of which are new and some old, which combination of parts as a whole gives superior safety, as well as other advantages.

And in regard to the omnibuses herein described, we claim as our invention the dividing the body into two parts, whereby passengers may enter at either side of the platform between the said bodies. We claim also the mode of suspending the body and locking the wheels in the manner described, and we claim, finally, the application both to the cabriolets and the omnibuses, of the indicator for measuring distances, though we wish it to be understood that we do not claim the invention of such an instrument, but merely its application in the manner described and for the purpose intended.

Rep. Pat. Inv.

Specification of the Patent granted to David Mushet, *of Coleford, in the County of Gloucester, Iron Master, for a certain Improvement in the art of making or manufacturing Bar Iron or Malleable Iron.*—Sealed October 22, 1835.

My improvement in the art of making or manufacturing bar-iron or malleable-iron relates to that part of the said art which is commonly termed the puddling process, being the process now most generally practised for converting crude or cast-iron into malleable-iron, by the action of heat and flame, in a particular kind of air-furnace, called a puddling-furnace. A patent was granted to Mr. Henry Cort, in the year 1784, for what is now termed the puddling process as aforesaid, and for clear comprehension of the meaning which I attach to several technical terms which must be used in this specification, I wish it to be understood that the term cast-iron is used to designate all the various qualities of crude-iron which are obtained from the smelting of ores of iron otherwise called mine, by the operation of what is called the blast-furnace, which operation produces fusible metal capable of being melted again, and which is commonly called cast-iron, because it can be cast by pouring it when in a fluid state into moulds; it is also called pig-iron or sow-metal, from the shape of the rude ingots into which it is cast when it is run out of the blast-furnace. Such crude or cast-iron is generally admitted to be iron combined with carbon, and it is supposed to derive fusibility from the carbon which it contains, and the various degrees of fusibility of cast-iron of different qualities are supposed to be very greatly influenced by different proportions of carbon being combined with the iron. The different qualities of cast-iron are designated in trade by numbers. Nos. 1, 2, 3, and sometimes 4; the highest number being considered the best quality and the most valuable, being the most fusible and supposed to be the richest in carbon. Nos. 1 and 2, otherwise called dark grey iron from the colour which it presents when newly broken, and No. 3 (which is called grey iron) are all used by iron founders for making castings, and hence are all called foundry-metal. The crude, or cast-iron, or pig-iron, which is made by the blast-furnace expressly for the purpose of being afterwards converted into malleable-iron, is commonly called forge pig-

iron, or bright grey iron; it is considered inferior in quality to either the Nos. 1, 2, or 3, used by iron founders, being less fusible than they require it to be, and it is supposed to contain less carbon; also a still less fusible quality of cast-iron than the bright grey, and supposed to contain less carbon, is occasionally made by blast-furnaces for conversion into malleable-iron; it is called mottled cast-iron from the colour of the fracture; and lastly, a very inferior quality called, from the colour of its fracture, white cast-iron is sometimes produced by the blast-furnace; it is more difficult of fusion, and is supposed to contain less carbon than the other qualities, and requires to be mixed with cast-iron of richer qualities. Before such cast or crude-iron called forge-pig or bright grey iron, or else mottled iron as aforesaid, is submitted to the puddling process before mentioned, for the purpose of being converted into malleable iron, the crude-iron is usually prepared for that process by a previous operation of melting in a furnace called a running-out-fire or furnace, otherwise called a finery, coke being used for fuel, and the fire being blown by a blast which is directed downwards upon the melted metal. After being so melted and run-out or refined the prepared cast-iron is called refined metal; now, in Staffordshire, it is called plated. By the operation of the running-out-fire or finery, the iron is supposed to be deprived of a portion of the carbon which it contained in the state in which it was first obtained from the blast-furnace, which deprivation is supposed to be owing to the dissipation or burning away of that said portion of the carbon in the running-out-fire or refinery, and the refined metal or plate becomes less fusible than it was before, which is a desirable preparation for undergoing the puddling process. Note, the aforesaid refining of crude, or cast, or pig-iron, by the running-out-fire, or finery, as a preparation for its conversion into malleable iron by the puddling process, was introduced after Mr. Cort's patent, and is not stated in his specification, but it has been the general practice for many years. The aforesaid different qualities of crude, or cast, or pig-iron, which are obtained from the blast-furnace, such as grey, mottled, or white, are mixed together when put into the running-out-fire or finery, in order to obtain a medium quality of refined metal or plate, and approximate as near as can be done towards uniformity in quality of the refined metal or plate, which is to be treated in the puddling-furnace, so as that operation may be conducted with regularity. The operation of the running-out-fire or finery is so conducted as to act more or less intensely upon the crude-iron which is subjected to it, according as previous experience has pointed out to be the most suitable, by way of preparing each quality of crude-iron, or each mixture of different qualities thereof, for conversion into malleable-iron in the puddling-furnace. The iron under these circumstances is supposed to be deprived of carbon until only such a portion remains combined with it as will render it most susceptible of conversion. When the running-out-fire or finery is managed so as to operate in its least degree upon the crude-iron (and as is supposed has had the least effect in depriving it of carbon,) the refined metal or plate which results, is said to be under blown, or it is said to be full blown, when the running-out-fire or finery operation has been carried further, and (as it is supposed) the metal has been deprived of still more of its carbon; crude or cast-iron so prepared, and called as aforesaid refined metal or plate, is said to be either under blown, or fully blown, or to be refined in any such intermediate degree between those extremes, as is found by daily experience to be most suitable to the quality or mixture of qualities of the crude-iron, for rendering it susceptible of being converted into malleable-iron by the pud-

dling-process. The puddling-furnace is of the kind called an air-furnace, and a suitable quantity or charge of the refined metal or plate, is heated therein by a strong fire of pit-coal, the flame thereof being urged by the draft caused by a high chimney to impinge upon the charge of metal, which becoming partially melted, or brought into a semi-fluid state, is then continually stirred up and turned over, in order that the current of flame may act equally upon all parts of the semi-fluid mass, which, after some continuance of the action of the flame, commences a sort of ebullition or effervescence from the effect of intestine motion called fermentation, during which the semi-fluid, called metal, appears to glow with increased heat, and a blue flame is emitted; the stirring and turning over is continued vigorously during the fermentation, in order that the whole mass may be subjected to a like action of the heat, until, by continuance thereof, the semi-fluid metal thickens by degrees, loses its fusibility, and becomes converted into malleable-iron, the actual conversion being termed by workmen, brought into nature; and it is supposed to be effected by the dissipation and burning away of the carbon which the iron still retained after the refining operation of the running-out-fire or finery. As the conversion proceeds and becomes complete, the iron, losing its fusibility, is said to become dry when it retains no fluidity, but gets into a crumbling or flaky state, and then the charge of iron is collected into masses or lumps of a convenient size, and the fire being urged for a short time to bring the metal to a white or welding heat, the masses are in that state withdrawn one after another from the furnace, and welded solid by blows of a heavy forge hammer, called a stamping or shingling hammer, and the rude mass of solid malleable-iron so obtained, before it loses its heat, is passed repeatedly between rollers, in order to reduce and flatten it to the shape of a rough bar, such bars are called puddled-bars of malleable-iron. The hammering is sometimes dispensed with, and the masses of hot iron when withdrawn from the puddling furnace, are passed between rough rollers to effect the welding, and then by continuance of the rolling the iron is formed into a puddle-bar. The rough puddle-bars so obtained are afterwards cut up into short lengths, and the pieces piled one upon another to form suitable masses called piles, which are heated to a welding heat, or as it is termed, re-heated in another air-furnace called a balling-furnace or re-heating furnace, and when withdrawn therefrom are welded together into a solid mass, by passing between rollers, and by continuance of the rolling, the iron is formed into a finished bar of malleable-iron. And note, it has become a common practice in South Wales, to revive or smelt what is called slag-cinder or scoria of iron, resulting from the waste which the iron undergoes by oxidation in the several processes of the art of making or manufacturing bar-iron or malleable-iron, as hereinbefore enumerated, that is to say, slag-cinder or scoria, resulting from oxidation of the heated iron, either in the operation of refining the crude-iron, in the running-out-fire or finery, or in the subsequent conversion into malleable-iron, in the puddling process, or in reheating in the balling or reheating furnace, or in the operation of the forge-hammer or rollers for welding the iron into solid masses, and forming those masses into puddled-bars or finished-bars. Such slag-cinder or scoria being mixed with the native ore of iron or mine, which is put into the blast-furnace, the iron in the slag-cinder or scoria becomes revived or smelted along with the iron contained in the native ore or mine, so that the slag-cinder or scoria, which would otherwise be wasted, becomes a substitute for a part of the native ore of iron or mine, which would otherwise be required, but such use of slag-cinder or scoria being

found to impair the quality of the iron which is so obtained, it is commonly found requisite in treating the same, to carry the refining operation of the running-out-fire, or finery to its full extent, in order that the refined metal or plate may be full blown as a preparation for its subsequent conversion into malleable-iron in the puddling-furnace. The use of slag-cinder or scoria as aforesaid, in the blast-furnace in admixture with native ore of iron or mine, in lieu of a portion of the ore or mine which would otherwise be used, produces a fusible quality of cast, or crude, or pig-iron, although otherwise inferior in quality; and it is not found desirable to have so great a degree of fusibility in the metal which is subject to the puddling process, because as before mentioned the metal is partially melted or brought to a semi-fluid state, when the aforesaid fermentation is excited, and the conversion into malleable-iron is effected. If the metal is too fusible when first put into the puddling furnace it will be quite melted therein, and must remain a longer time exposed to the action of the current of the flame, in order to thicken and acquire that consistency which is favourable for the commencement of the fermentation. The treatment of the metal in the running-out-fire or finery, is endeavoured to be carried to that extent called full-blown, or to any intermediate state between that and what is called under-blown, which is found by experience to be adapted to the quality of the crude or cast, or pig-iron, or mixture of qualities thereof, which is put into the running-out-fire or finery, so as to obtain refined metal or plate, which in respect to fusibility, conjointly with other qualities, is found most susceptible of conversion into malleable-iron in the puddling-furnace.

All the above particulars are fully known to persons conversant with the iron manufacture, but what is herein-before stated, contains no part of my invention, and is only introduced by way of explanation of the meaning which I attach to the terms which I use in describing my invention.

My said improvement in the art of making or manufacturing bar-iron or malleable-iron, consists in adding to the iron which is undergoing the puddling process in the puddling-furnace, rich native ore of iron in a state of powder, throwing suitable small quantities thereof at a time into the puddling-furnace upon the semi-fluid iron, so that the said powder will become intermixed with the said iron, in consequence of the manipulation or action of turning over and stirring up, which the semi-fluid iron must receive during the usual course of the puddling process; or together with the said powder of rich native ore of iron, I use charcoal, or else coal, reduced to a state of powder and intimately mixed with the powder of ore, and suitable small quantities of such powder of rich native ore of iron, either with or without powder of charcoal or coal, being from time to time added to, and intermixed with, the semi-fluid iron as aforesaid, previous to the commencement of, and during the progress of, the effervescence or fermentation hereinbefore mentioned, which precedes and accompanies the conversion of iron into a malleable state, the said fermentation is increased and the thickening of the iron is accelerated, and its coming into nature, or conversion into the malleable state is facilitated so as in the result to effect an improvement in the making or manufacturing of bar-iron. The beneficial result obtained by the improvement being in some cases, that a given weight of bar-iron can be made, by aid of the improvement, from a less quantity of crude, or cast, or pig-iron, than would be required in the ordinary course of proceeding of refining the said iron, in the running-out-fire or finery, and then puddling the refined metal or plate without the improvement; the quality of the bar-iron being as good in one way as the other, or in other

cases the beneficial result will be in making bar-iron, by aid of the improvement, of a superior quality, to that which would be produced from the same crude, or cast, or pig-iron, by the ordinary course of proceeding without the improvement, the weight of crude, or cast, or pig-iron, required to make a given weight of bar-iron, being the same in one way as the other; or in other cases the beneficial result will be in making bar-iron, by aid of the improvement, of a better quality from a smaller proportion of crude, or cast, or pig-iron, than is done by the ordinary course of procedure without the improvement.

My said improvement, consisting as aforesaid, in adding rich native ore of iron in powder, either with or without powder of charcoal or coal, and mixing small quantities thereof, from time to time with semi-fluid iron which is undergoing the puddling process, so as by such addition and mixture to increase the fermentation and accelerate the conversion of that iron into the malleable state. My said improvement is supposed by me to operate, by a tendency which the rich iron ore may have to facilitate and expedite the separation of carbon, from the semi-fluid iron, when the said ore is very suddenly heated by its application in small quantities, and in a divided state, to the iron, which is already in a semi-fluid state, and consequently very hot, and that heat kept up by the continual action of the flame of the furnace. The quantity of rich ore which is thrown in at once being small, its tendency to lower the heat of the semi-fluid iron may be overcome in a great degree by keeping up the fire strongly; and by the turning over and stirring manipulation the powder is intimately mixed with the whole mass of semi-fluid iron as quickly as possible, and then the ore becoming suddenly and strongly heated, I suppose it may facilitate and expedite the extraction of carbon from the semi-fluid iron, for the addition of powder of iron ore, according to my improvement, visibly promotes and assists the intestine motion and effervescence or fermentation which the semi-fluid iron usually undergoes, and which is supposed to be occasioned by the departure of the carbon from the iron, during its conversion into the malleable state. But note, as the aforesaid supposition of the ore operating beneficially by facilitating the extrication of carbon does not admit of direct proof by any experiment which I have made, the same is only offered as a supposition in explanation of the mode whereby my improvement may produce those beneficial results which I have obtained from it, in many repeated trials on a large scale of actual practice. The iron which is contained in the rich ore, which according to my improvement is added to, and mixed with the semi-fluid iron, tends as far as it goes to increase the quantity of malleable-iron beyond that which would otherwise be produced without my improvement, and also tends to improve the quality of the malleable-iron, and give the bars thereof a more fibrous texture than they would otherwise acquire; and for the full explanation of the manner of performing my said invention, I will now state the mode of procedure, which I have found by experience to be most beneficial for making or manufacturing bar-iron or malleable-iron by aid of my improvement. The ore of iron which I employ for my improvement, may be of any kind which is rich in iron. I have used the rich-iron ores obtained in the forest of Dean, in Gloucestershire, called brush-ores, and which are considered to be of the nature of hydrous-oxides of iron, containing about sixty per cent. of their weight of metallic iron; and I have also used the rich Cumberland iron-ores, called blood-stone, or haematites, from their red colour, and which are considered to be of the nature of oxides of iron, containing more than sixty per cent.

of iron; and I have also used the rich Lancashire iron-ores, which are considered to be of the same nature as the Cumberland ores, but generally containing less iron, being from fifty to sixty-three per cent. There are many kinds of rich iron-ores, obtained in foreign countries which would answer the same purpose, but as it is not usual to import such ores of iron in quantity into this country, I have not had an opportunity of making trial of any foreign ore of iron, excepting one kind brought from the East Indies, and which is used there for making the iron from which the East Indian steel called wootz is made; but inasmuch as such rich foreign ores of iron would be substitutes for those obtained, as aforesaid, from Gloucestershire, Cumberland, or Lancaster, such rich foreign ores of iron, as well as other rich ores of iron which may possibly be obtained from other parts of Great Britain than those which I have enumerated (although as yet unknown to me,) will I expect be available for carrying my invention into effect, as the same does not depend upon any peculiarity of the ore of iron which is used, provided that the same is rich in iron, and free from (or separated from) any minerals which are inimical to the reduction, by action of heat, of the iron contained in such ores into a metallic state, and also provided that the said rich iron-ore is capable of being broken or ground to a state of powder. The rich ore of iron which I use is to be reduced to powder small enough to pass through a wire sieve or riddle, containing about 300 holes or meshes in each square inch, but the finer the powder the better it will operate, and hence if the nature of the ore will permit of reducing it easily to a fine dust, it will be advisable to do so. The ore may be broken and powdered fine by stampers of the same kind as are commonly used in Cornwall for reducing tin ores to powder; or it may be ground by rolling stones, called runners, on edge, such as are used in the making of gunpowder; or the iron ore may be crushed between iron rollers, or it may be ground fine by the same kind of machinery which is commonly used by iron-founders for grinding charcoal to make what they called moulder's blacking for applying to the moulds in which iron is to be cast, and which machinery is well known to all persons conversant with the iron manufacture; or the iron ore may be first crushed or broken small by one kind of machinery, as aforesaid, and then ground to fine powder by other kind of the said machinery, as is most suitable for getting the iron-ore into a state of minute division. The rich iron-ore which is used may be prepared by previous calcination or roasting; but I have not found any sensible difference in the efficacy of the powder of Gloucestershire, Cumberland, or Lancashire ores, when the same have been prepared by wasting, or have been reduced to powder without wasting; nevertheless, if a moderate wasting will facilitate the breaking and grinding of the ore to powder, it may be advisable to do so, but whether that will be the case or not will depend upon the texture of the particular ore which is used, and the nature of the machinery which is employed for breaking or grinding the ore, and in case powder of charcoal or coal is to be mixed with the powder of rich iron-ore, the same is to be ground fine by any of the machinery before mentioned, that which is used for grinding moulder's blacking being very suitable, and either charcoal of wood or what is called animal charcoal may be used, the latter being commonly made from bones, or from the hoofs of animals, or scraps of leather. The proportions in which I have found it advisable to use rich ore of iron in powder in the puddling process, according to my improvement, are as follows: to make common bar iron by aid of my improvement I charge the puddling furnace with about four hundred and fifty pounds weight of crude, or cast, or pig-iron,

varying in quality from between what is designated bright grey and mottled approaching to white, mixing together such portions of the different qualities which are within that range of variations as previous experience has pointed out, for producing an average quality in a long series of successive charges, so as to bring the operations of converting those successive charges into malleable-iron to regularity of repetition.

And note, the selection of those said qualities, and the proportions in which they are to be mixed together, and the said averaged quality which it is desirable to produce, must be regulated by the same judgment and discretion which is commonly exercised by iron masters in selecting and mixing the crude, or cast, or pig-iron, which is to be put into the running-out-fire or finery, when they intend to prepare the same for making common bar-iron without the aid of my improvement; such judgment and discretion can only be acquired by experience, and cannot be communicated by writing, because of the numerous gradations of quality in crude, or cast, or pig-iron, which do not admit of accurate description, but it is sufficient to say that the aforesaid charge of about four hundred and fifty pounds which I put into the puddling-furnace, may be of the same quality or mixture of qualities of crude, cast, or pig-iron as is usually put into the running-out-fire or finery, in order to be prepared for making common bar-iron, but when the same bar-iron is to be made by aid of my improvement, the previous preparation of refining by the running-out-fire or finery may be dispensed with, and the crude, or cast, or pig-iron charged at once into the puddling-furnace, as was formerly practised by Mr. Cort, during the term of his patent of 1784. The management of the puddling-furnace is to be the same as usually practised (that is to say:)—before it is charged the furnace must be brought to a proper heat, and the iron bottom of the furnace prepared in the usual manner for the reception of the charge, by laying on a proper quantity of slag, cinder, or scoria, which has been separated from previous puddle-balls or re-heated piles of puddle-bars by operation of the forge hammer or rough rollers; but, note, after the charge of iron is put into the puddling-furnace with its iron bottom so prepared, no more slag, cinder, or scoria, is to be thrown in during the operation of melting or converting the iron, when by the usual routine course of procedure with puddling-furnaces, the said charge of crude, cast, or pig-iron begins to be melted so as to be capable of being stirred up and turned over with the iron tool which the workman uses for that purpose; then the application of my improvements is to commence by throwing upon the partially melted iron about two pounds weight at a time of powder of rich ore of iron, either with powder of charcoal or coal intermixed, or without, the iron being well stirred and turned over after every time that a dose of powder is so thrown upon it, in order that the powder may become intimately mixed with every part of the charge of iron. The fire should be kept up so that the heat of the iron will not become materially less than would be desired in the usual practice, notwithstanding the throwing on of the powder, and as soon as one dose of powder which has been thrown on and mixed up with the iron appears, together with the semi-fluid iron, to be at the full heat which the iron ought to have, according to the ordinary process, then another dose of about two pounds more of the same powder may be thrown on and mixed with the iron as before, and when the iron gets again to a full heat, another like dose may be added, and so on, always turning over and stirring the semi-fluid iron and intermixing each small dose of the powder as completely as possible with every part of the charge, and always keeping up the heat of the

iron as near as can be to what would be done in the usual way of puddling, if my improvement were not used; in this way I add about as much powder of iron ore as will amount by weight to one-eleventh part of the weight of crude, or cast, or pig-iron with which the puddling-furnace is charged, or about forty pounds weight of such powder to the aforesaid charge of about four hundred and fifty pounds of iron, or in case powder of charcoal or coal is intermixed with the said powder of ore, then the weight of charcoal or coal will be at the rate of about one-sixteenth part of the weight of ore with which it is mixed, which will increase the said forty pounds of powder to about forty-two and a half pounds to a charge of about four hundred and fifty pounds of iron. The manner of adding the powder to the semi-fluid iron will be the same, whether it contain a mixture of charcoal or coal, or not, except that it may be found expedient to wet or damp the powder which contains a mixture of charcoal or coal with water before throwing it on; and note, such damping may be given when the powder does not contain a mixture of charcoal or coal, if the workman finds it desirable, all which is to be managed according to his experience in the working of the iron and its heat, in the same manner and with the same discretion as water is occasionally thrown into the puddling-furnace in the ordinary course of procedure. The usual fermentation of the iron will be increased, and its conversion into the malleable state, or coming into nature, will be facilitated by the addition of the powder according to my improvement, in manner aforesaid; and after that addition is made, the process is to be continued and concluded in the usual manner of puddling and making the iron into puddle-bars of common iron, without variation from the usual routine.

On account of my improvement I find that a ton or twenty hundred weight of puddle-bars can be made in the manner above explained by aid of my improvement from twenty one and a half hundred weight of crude, cast, or pig-iron, or from twenty and three quarters hundred weight thereof, when the powder of rich iron-ore is intermixed with powder of charcoal, as above explained. The quality of the puddle-bars so made being the same common iron as would be obtained by the usual mode of refining the crude, cast, or pig-iron, in the running-out-furnace or finery, and then puddling the refined metal or plate in the usual manner without aid of my improvement, but as that aid permits the preparatory refining operation to be dispensed with, a great saving of waste is attained, and although I have stated one eleventh of the weight of the charge of crude, cast, or pig-iron, as a proportion for the powder of rich iron-ore which may be used, the same may be varied with advantage in different cases, from one-eleventh to one-eighteenth, according to the nature and fusibility of the iron, and that if the rich ore which is used, the best proportion for every particular sort of iron and of ore, can only be determined by the discretion of the iron-master taking experience for his guide. To make bar-iron of a first rate quality by aid of my improvement, I take crude, cast, or pig-iron, of a richer quality than is usually employed for converting into malleable-iron, being such as is used by iron founders, and commonly called No. 2. grey iron foundry-metal, and which metal has been made without putting any slag, scoria, or cinders, into the blast-furnace. The mode of procedure is to be the same as last explained, putting a charge of about four hundred and fifty pounds of such No. 2, grey iron, into the puddling-furnace, and adding thereto about one-eighth part of its weight, or about fifty five pounds of powder of rich iron-ore, applying the same in successive small doses, in manner hereinbefore described, which will assist the

fermentation and facilitate the conversion into malleable-iron. And I find that a ton or twenty hundred weight of puddle-bars of the first rate quality can be made in that way by aid of my improvement, from about twenty one hundred weight and three quarters of the said No. 2, crude, cast, or pig-iron, which is put into the puddling-furnace. Or from about twenty-one hundred weight thereof, if powder of charcoal is intermixed with the powder of rich iron-ore, the weight of powder of charcoal being about one-sixteenth of the weight of the powder of ore with which it is mixed, and although by aid of my improvement, the use of running-out fire or finery may be dispensed with, and Mr. Cort's original practice of puddling crude, cast, or pig-iron, as it comes from the blast-furnace, may, by aid of my improvement, be rendered fully available in practice; nevertheless my improvement is applicable with advantage to the puddling and conversion of refined metal or plate into bar-iron or malleable-iron. In such case I take such refined metal or plate as would be usually denominated under-blown, and which, in undergoing the operation of the running-out-fire or finery, will have lost in weight from eight to ten per cent. of the weight of the crude, or cast or pig iron, which was put into the running-out-fire or finery, and of such under-blown refined metal or plate I put into the puddling-furnace a charge of about four hundred and fifty pounds, and add thereto about one twentieth part of its weight or about twenty five pounds of powder of rich iron-ore applied in small successive doses in manner hereinbefore described, and I find that a ton or twenty hundred weight of puddle-bars can be made in that way from about twenty hundred and three quarters of the refined metal or plate which was put into the puddling-furnace, or from only twenty hundred weight thereof (or even less) when the said powder of rich iron-ore is intermixed with about one sixteenth part of its weight of powder of charcoal, in manner already explained; and the quality of the bar-iron thus made by aid of my improvement will be found equally fibrous as if it had been made in the common mode without any improvement. Or in applying my improvement, in case of puddling refined metal or plate, which has been fully blown by previous operation of the running-out-fire or finery, I put about four hundred and fifty pounds thereof into the puddling-furnace, and add about one-thirtieth part of its weight of powder of rich iron-ore, or about fifteen pounds thereof to the said charge, and in case such refined metal with such addition should not be found to melt so thin as is desirable for the proper working of the iron in the furnace, then from thirty to sixty pounds, or more, of grey melting iron may be mixed with the refined metal or plate, when the furnace is charged, and the said four hundred and fifty-pounds being made up by so mixing will have acquired more fusibility; and I find that a ton or twenty hundred weight of puddle bars can be thus made, by aid of my improvement, from about twenty hundred weight and three quarters of fully blown refined metal or plate, or from about twenty hundred weight and one-quarter thereof, when powder of charcoal, at the rate of about one-sixteenth part of the weight of the powder of iron-ore is intermixed therewith, as before explained; or for applying my improvement in case of puddling mixture of equal parts of fully blown refined metal or plate, and of crude, cast, or pig-iron which has not been subjected to the operation of the running-out-fire or finery, I put a charge of about four hundred and fifty pounds of such mixture into the puddling furnace, and add thereto about one-fifteenth of the weight of the charge, or thirty pounds of powder of rich iron-ore, and I find that a ton, or twenty hundred weight, of puddle-bars can be made in

that way from about twenty-one hundred weight of the aforesaid mixture of iron, which was put into the puddling furnace, or from about twenty hundred weight thereof (or even less,) when powder of charcoal is mixed with the powder of ore in manner aforesaid; and although I have mentioned the proportions of powder of iron ore, with or without mixture of powder of charcoal, which I have found to answer best for performing my improvement with effect in several cases, which will be found to comprise the most usual circumstances of the manufacture of bar-iron, nevertheless those proportions must be varied to suit various circumstances, and as some guide to those variations, it may be observed that the more fusible the iron is which is put into the puddling-furnace, so a greater proportion of the powder of rich iron-ore may be used with advantage for the performance of my improvement, but if a greater quantity of such powder is added than is suitable to the fusibility of the iron, it will thicken too much and partially, so as to agglutinate into lumps which are unmanageable, and that should be avoided; and on the other hand, if the iron does not thicken so soon, or become converted into the malleable state as quickly as it might do, and as is desirable, or, as the workmen say, if it continues too long wet, then by adding more of the powder of such iron-ore it will thicken or become dry and ready for withdrawing from the furnace, the tendency of adding powder of iron-ore, according to my improvement, being in all cases to expedite the conversion of the iron into a malleable state in the puddling-furnace, and when powder of charcoal or coal is intermixed with powder of rich iron-ore, as hereinbefore stated of the powder of charcoal, being one-sixteenth of the weight of the powder of iron-ore, I have found to answer the purpose, but that proportion may be varied, and respecting the application of my improvement in cases of puddling crude, or cast, or pig-iron, which has been made by putting slag, cinder, or scoria along with ore or mine into the blast-furnace according to a practice before explained, although the same may be puddled without an absolute necessity for a previous preparation in the running-out-fire or finery, nevertheless I prefer and recommend that such pig, or crude, or cast iron, should be prepared by the operation of the running-out-fire or finery, and thereby blown or refined to such a degree as may be most suitable to its peculiar quality in the same manner as is now commonly practised with such metal, and then to charge the puddling-furnace with such refined metal, and to apply my improvement during the process of puddling the same, in the manner hereinbefore directed, for puddling refined metal or plate.

Having now described the nature of my improvement, and the manner in which the same is to be performed, I, the said David Mushet, do hereby declare that the new invention whereof the exclusive use is granted to me by the said letters patent, consists in adding rich native ore of iron in powder (either with or without intermixture of powder of charcoal or coal) to iron which is undergoing the process of puddling in the puddling-furnace, in order to be by that process converted into the malleable state, and manufactured into bar iron.—In witness whereof &c.

Enrolled April 22, 1836. Ibid.

Specification of the Patent granted to John Isaac Hawkins; *of the County of Middlesex, Civil Engineer, for an improvement in the Blowing Pipe for Blast-Furnaces and Forges.*—Sealed September 28, 1836.

The improvement consists in so forming the mouth or mouths of the blowing-pipe as to deliver the usual supply of air into the furnace or forge

in a thin sheet or in thin sheets, possessing great surface in proportion to the bulk or volume of the stream of air, in order that the air may impinge upon and impart its oxygen immediately into a large quantity of the ignited fuel, the more advantageously to promote combustion, and also to avoid the comparatively chilling effect which is produced by the pouring in of cold air in a body of considerable thickness, as in the case in the ordinary mode of delivering it through a circular orifice, or through two, three, or even four circular orifices.

He adds, I sometimes enlarge the common circular orifice of the mouth piece or extremity of the blowing-pipe next to the fire to three or more times the usual diameter, and place a conical plug concentrically within the same, with the apex of the cone pointing towards the bellows or blowing machine, and the base of the cone lying even with the end of the mouth-piece towards the fire, or, lying a little within or a little without the end of the mouth-piece, the dimensions of the base of the cone being such as shall leave an annular aperture or air passage between the cone and the pipe, equal in area to the area of the ordinary mouth-piece or to the conjoint areas of both, or of all the mouth-pieces when two or more are used. By this arrangement the air is delivered in such a thin cylindrical sheet that its contained oxygen will find immediate access to the ignited fuel, and augment the intensity of the heat more advantageously than can be effected by a thick stream of cold air, or by two, three or four such streams; and I support and retain the cone in its place within the pipe or mouth-piece by means of two pins or bars passed horizontally through the sides of the pipe and through the sides of the cone, the pins or bars crossing at right angles the common axis of the cone and of the pipe; and I also place lateral guides to assist in keeping the cone concentric with the pipe, and I sometimes elongate the two holes in the cone, so that the cone may slide a short distance across the pins in the line of the common axis of the cone and of the pipe, upon being moved by a lever having its fulcrum in, or near, the side of the pipe, one arm of the lever projecting outward from the pipe, to which arm the power may be applied, and the other arm within the pipe reaching to the apex of the cone where it takes hold of a link affixed in any common manner to the apex of the cone. The lever, on being moved on its fulcrum by its outer arm lengthwise of the pipe, will cause the inner arm to move the cone in the line of the common axis of the cone and of the pipe. And I sometimes make the extremity of the mouth-piece surrounding the base of the cone a little conical, enlarging outwards towards the fire, whereby the sliding of the cone in the common axis will enlarge or diminish the area of the annular aperture, according as the sliding cone is carried towards or from the fire. And I sometimes carry the invention into effect by making the blowing-pipe with two or more branches, each branch terminating in a mouth-piece having a long narrow orifice, delivering the air into the furnace or forge, in a thin broad sheet, the conjoint areas of all the oblong orifices being equal to the area of the single circular orifice as commonly used. And in the case of a blast-furnace whether of the large kind for smelting of iron or of the smaller kind called a cupola in which cast-iron is melted, I distribute the mouth-pieces around the furnace so as to deliver the thin broad sheets of air into the fire at nearly equal distances. And in case of a forge I distribute the mouth-pieces at equal distances along the fire according to the length required to be heated, and I place the greatest dimensions of the orifices vertically and make them of such a height as shall the most effectually blow up a fire to the altitude required. And I sometimes make use of five or

more mouth-pieces with circular orifices, but although they are much superior to a less number, I do not deem them so advantageous as the oblong form hereinbefore described. Ibid.

NOTE. This patent was obtained for the inventor, JOHN BARKER, of Baltimore. EDITOR.

Sugar:—Examined in its Commercial and Chemical Relations. By GEORGE GUYNNE and JAMES YOUNG.

(Continued from p. 180.)

We are inclined strongly to doubt the received opinion that it is the carbon of the charcoal which is the decolorating agent. That carbon alone has decolorating properties, appears certain from M. Bussy's elaborate paper (*Jour. de Pharm.* for June, 1822;) still we believe that the carbon takes away from raw sugar the aroma alone, and that it is the peroxide of iron and phospate of lime, which animal charcoal contains, that renders it useful in sugar refining. If some "grained" charcoal is burned to perfect whiteness, by destroying its carbon, and some raw sugar liquor is percolated through it, no decoloring takes place. This appears conclusive in favour of the carbon; nevertheless we would explain it in a different manner. Animal charcoal contains (besides other bodies not bearing on this question) carbon, peroxide of iron, phosphate of lime, and carbonate of lime. During the combustion in the open air, the carbonate of lime is decomposed, and converted into caustic lime, and part of the peroxide of iron into the protoxide of iron. Now as caustic lime forms soluble compounds with the vegetable foreign bodies in sugar, and, as its affinity is much greater than any of the oxides of the second class of metals, no decoloration takes place. But if the bone-ash is washed with diluted acetic acid, to neutralise the lime, and the acetate of lime formed thereby washed entirely away, the "bone-ash" dried to expel the water, and some raw liquor now percolated through it, considerable decoloration takes place; not quite so much certainly as before burning. This difference we believe is caused solely by the conversion of part of the peroxide into protoxide of iron; protoxide having no affinity whatever for either mucilage or gluten. These views receive confirmation from the following experiments. If three parts of hydrated peroxide of iron, and 97 parts of diphosphate of lime (neutral phosphate,) whilst still moist, are intimately blended together, placed on a water-bath, and perfectly dried, and then carefully pounded into grains and "raw liquor," percolated through, this composition will be found fully as powerful in decolorating as any animal charcoal obtained from bones.

If some of the carbonate of iron of the apothecary, which is well known to be a mixture of peroxide and carbonate of protoxide of iron, is diffused through water and some clean washed coarse grained sand is mixed with it, and the whole carefully dried at a boiling-water heat (212°,) so as to get the oxides to form a red coating round each grain of sand, and some raw liquor percolated through the "bed,"* it will prove to be a much stronger decolorating agent than animal charcoal. If the "liquor" is tested, it will not show a trace of iron. The action which takes place in this experiment is, the carbonate of protoxide of iron, owing to its very feeble affinity, is decomposed by the lime in the sugar, which is converted into the carbonate

* Percolating is an excellent means of forming saturated solutions of salts, like the permuriate of iron, which are troublesome to prepare by the usual mode. Dry the substance on the sand bath, and, if for the permuriate of iron, allow muriatic acid very slowly to filter through the salt till thoroughly saturated.

of lime, and the peroxide of iron instantly unites with the mucilage, &c. The oxide of iron, which the raw sugar originally contained, being totally insoluble in liquor, without the aid of either an acid, alkali, or alkaline earth; and in this case, it being lime which rendered it soluble, and that body being abstracted, the oxide of iron falls down insoluble also. We may remark here, that pure peroxide of iron is insoluble in liquor containing lime. If such liquor is boiled for some time on peroxide of iron, the peroxide is partially deoxidised, and becomes converted into protoxide, which is immediately dissolved. The oxide of iron in raw sugar, although minute in quantity, materially darkens the colour. The best mode of detecting its presence is by adding a few drops of solution of ferro-sesquicyanuret of potassium to some "raw liquor," contained in a test tube, shaking well, and then putting in a few drops of diluted sulphuric acid, and again shaking, the distinctive colour immediately appears. The sulphuric acid is necessary, because the ferro-sesquicyanuret of potassium does not indicate the iron unless the quantity is considerable; whereas, with the acid, the oxide of iron can be detected to the $\frac{1}{80000}$ part.

On filtering "raw liquor" through grained charcoal, we believe the action to be similar to that given of the carbonate of oxide of iron. The phosphate of lime unites with the lime contained in the liquor, and is converted into the triphosphate. The peroxide of iron unites with the mucilage, gluten, and tannic acid, the carbon absorbs the aroma, and the protoxide of iron is precipitated; the lime being abstracted by which it was held in solution in sugar.

That the phosphate of lime plays an important part in decolorating sugar, will receive strong confirmation from the effect it produces when mixed with that matter called the *residuum* of the Prussian blue makers. This charcoal, from its powerful decolorating properties, has been repeatedly tried in the sugar-house, but always abandoned from the injury it has been found to do the sugar. It is well known to contain a large quantity of oxide of iron; when mixed with raw liquor, the lime and sugar dissolve the oxide of iron, and here the injury takes place. Now, in order to prevent this, all that is required is to mix some diphosphate of lime with the *residuum*. The diphosphate abstracts the lime from the liquor, and when this takes place the oxide of iron is no longer soluble.

It may appear strange that as animal charcoal contains only a small quantity of peroxide of iron, the precipitation of mucilage, &c., can be due to this body, because it requires an immense quantity of charcoal to decolour "raw liquor" perfectly. This may be met with saying that all the impurities in 112 lbs. of raw sugar do not really weigh more than a few ounces, certainly not half a pound. The following will prove this to be true. Let a quantity of animal charcoal, in grains, be washed repeatedly with boiling water, in order to carry away the impure carbonate of ammonia it always contains when new. Let it now be heated to redness, in a retort, which will prevent access of air, and then allowed to cool completely without exposure; as soon as it is quite cold, it should be put into a suitable vessel, with a perforated false bottom, to the depth of 36 inches, and raw liquor allowed slowly to percolate through the bed of charcoal. The liquor which comes through, if tested, will be found perfectly free from mucilage, gluten, tannic acid, oxide of iron, and lime, and its crystallising power much increased. The only foreign bodies which it contains, are faint traces of acetate of lime and chloride of sodium. Let the sp. gr. of the "raw liquor," before pouring on the charcoal, be taken very accurately, along with the temperature; let this sp. gr. be, say 1.2800 temp. at 60°. If

the sp. gr. of the liquor which first comes through the bed of charcoal be accurately taken, it will be found to be 1.2795 at 60°; any person with an accurate balance can be satisfied that this minute difference in the sp. gr. will not amount to more than a few ounces of foreign bodies in 112 lbs. of raw sugar.

It is the custom of those sugar houses, in which "grained charcoal" is used, to have it reburned in a retort again and again; but after a time the decolorating power of the charcoal becomes lessened, and this deterioration gradually increases until it arrives at a point where it is more economical to buy new charcoal than to reburn the old. This deterioration arises partly from the lime contained in the sugar being gradually deposited, and which cannot be got rid of by burning, slowly converting the bone phosphate into the triphosphate of lime. When this is accomplished throughout the entire charcoal, no farther abstraction of lime from the liquor takes place, and the grain thereby suffers injury. The "finings" which the sugar refiners use contain sulphate of potash, and this sulphate, as it slowly passes through the charcoal, becomes decomposed; the decomposition ending in sulphate of lime and phosphate of potash; the sulphate remains in the charcoal and gradually incrusts the peroxide of iron. The decomposition of the mucilage, &c., by burning, produces an increase of pure carbon, which also covers the peroxide of iron.

After a careful examination of the advantages and disadvantages attending the employment of grained charcoal, we believe that the *best* plan now in operation in Great Britain admits of considerable improvement. A simple experiment will prove that the refiner does not obtain all the *grain* raw sugar is capable of yielding by this plan. The "green sirups" produced in the sugar house from "raw sugar," which has passed through grained charcoal, yields the refiner a *poor article*, nothing at all approaching the quality of refined sugar. Let some new grained charcoal be carefully washed with hot water and dried; prepare a suitable vessel for filtering, and allow some green sirups of the above kind slowly to percolate through. If the first liquor which comes through the charcoal be boiled in a vacuum pan, and afterwards treated as for making refined sugar, an article will be produced equal in quality to the *double standard* of the London customs. Some of the refiners have attempted to do something like this, but they found that the quantity of charcoal required was so enormous, and they were so inundated with *sweet waters*, so as to make the ordinary method of disposing of the green sirups far preferable.

Of the foreign bodies existing in raw sugar which it is practicable to remove, three (mucilage, gluten, and tannic acid) are vegetable, and two, (oxide of iron and lime) are mineral bodies. It is evident, therefore that no one agent can remove bodies so dissimilar in properties.

Of the vegetable bodies, tannic acid alone has any thing approaching to a strong decomposing power. The affinities of mucilage and gluten are of the most feeble kind, incapable of neutralising either acids or alkalies. It is evident, therefore, that the mere change in the nature of mucilage and gluten will answer no useful purpose; they must be entirely removed from the sugar.

As lime forms soluble salts which are neutral to test paper, it may be converted into acetate of lime which does no injury to the sugar; not so the oxide of iron, for as all its soluble salts have an acid reaction on test paper, they must be precipitated.

In seeking for agents suitable for the above purposes, two essential cir-

cumstances should be borne in mind; viz., that they must be cheap, and that they do not injure the "grain" of the sugar. A failure in either of these conditions would be fatal to their employment. If two ounces of an article as expensive as nitrate of oxide of silver would remove every impurity from a cwt. of raw sugar, or a body such as chlorine, which injures the grain, would do the same, neither could be employed on the large scale.

Overlooking tannic acid, for the present, let us turn our attention to mucilage and gluten, which are soluble in acids; and as they must be entirely removed from the sugar, it is plain that the employment of any of that extensive class of chemical agents comprehended under the denomination of acids, and other bodies possessed of nearly similar properties (as chlorine, &c.,) are totally useless for this purpose, because their application would only produce a mere change in the nature of mucilage and gluten. These bodies being also soluble in alkalies and alkaline earths, and none of their salts having any power of precipitating mucilage and gluten, they are likewise inadmissible.

Several oxides, such as alumina, peroxide of iron, oxide of lead, &c., when in the hydrated state, will precipitate colouring matter from "raw liquor," and their powers in this respect are considerably increased by being mixed with bodies, such as diphosphate of lime or carbonate of oxide of iron, which have the power of abstracting the lime from the "liquor," but the quantity required of any hydrated oxide to remove the entire mucilage and gluten from sugar is so very great as totally to prohibit their employment for the above purpose. The following case will prove this. Animal charcoal, in fine powder, is much more powerful as a decolorating agent than alumina, peroxide of iron, &c. To effect the degree of improvement now obtained in the sugar houses (by percolation through grained charcoal,) would require 50 lbs. of finely powdered charcoal for 112 lbs. of raw sugar. This "fine" charcoal cannot have its strength restored in the ordinary way like the "grained" charcoal; it must be rejected as waste; besides this, the quantity of "*sweet waters*" produced by using so large a quantity would be ruinous to the sugar refiner. To show the difference still more characteristically, it will be found that if "grained" charcoal be employed in the same way as "fine" charcoal diffused through the liquor, by stirring, that one pound of "fine" will destroy more colour than four lbs. of "grained" charcoal. It has been found by experience that a greater proportion than 5 lbs. of fine charcoal to 112 lbs. of raw sugar cannot be employed advantageously. Now what experience has proved of "fine" charcoal, applies most strictly to metallic oxides. They cannot be used so as to make an improvement on the present process of sugar refining.

The salts of the second class of metals may be divided into soluble and insoluble salts. Where any of the insoluble salts, such as the disulphate (subsulphate) of peroxide of iron, dinitrate (subnitrate) of oxide of lead, &c. precipitate mucilage and gluten, it will be found that the same objections which prevented the employment of hydrated oxides prevail equally here.

The soluble salts may be divided into three classes; first, those which are composed of an equivalent of acid and base; second, those which have two or more equivalents of acid to one of base; third, those which have two or more equivalents of base to one of acid.

Vegetable principles possessed of affinities so feeble as mucilage and gluten are incapable of abstracting the base from the salts of the first or second class, without the aid of some alkali or alkaline earth; as, for instance, the tersulphate of peroxide of iron (persulphate of iron,) will not

precipitate pure mucilage when dissolved in distilled water; but if the mucilage is dissolved in lime-water, immediate precipitation ensues if no excess of tersulphate has been employed. It has been shown, in an earlier part of this paper, that it is impossible to decompose a salt when in solution in "liquor," by the aid of an alkali or alkaline earth, without such decomposing body being in excess; now as alkalies, &c. injure the "grain" and "colour" of sugar, independent of the property they possess of dissolving mucilage and gluten, it follows that salts of the first and second classes can not be usefully employed as precipitators. Triacetate of oxide of lead (subacetate,) will be found the cheapest and most powerful precipitator of mucilage and gluten amongst the few salts constituting the third division; it also forms an insoluble compound with tannic acid.

Having given ample directions for its use in another place, it only remains for us to state, that its employment, according to our instructions, will greatly improve sugar refining as practised in this country, and prove of most essential service to the planter as a substitute for "temper," removing any impurity from cane juice. Believing that the period will arrive when triacetate of oxide of lead will be used for the purpose of removing vegetable impurities from sugar, we shall examine the mineral bodies (lime and oxide of iron) contained in raw sugar, along with the oxide of lead left in the liquor by its employment.

Acids, as oxalic, sulphuric, &c., which form insoluble compounds with lime and oxide of lead, cannot be used with advantage in the removal of the above bodies from "liquor," for an excess of acid must be employed for effecting this object; this excess will destroy the "grain," and it cannot be corrected by the aid of alkalies, &c., without such bodies also being in excess.

Acids can be neutralised or precipitated, when dissolved in liquor, by diffusing through such liquor suitable inert bodies, such as carbonate of lime, and carbonate of magnesia, without producing injury to the grain. But the objection which causes the rejection of the metallic oxides in practical sugar refining, prevails equally against the employment of carbonate of lime, &c., by diffusion, for neutralising acids existing in liquor. The only practical method of neutralising acids in liquor is, by allowing the liquor to percolate through a bed of suitable, insoluble material, as carbonate of lime, &c., in the manner described by us in our specification.

There are several salts, as sulphate of soda, ferrocyanuret of potassium (prussiate of potash,) oxalate of ammonia, &c., which will completely decompose the soluble salts of oxide of lead, when water is the medium in which they (salts of lead) are dissolved. If liquor has acetate of oxide of lead dissolved in it, and is itself not acid to test paper, no excess of sulphate of soda, ferrocyanuret of potassium, &c., will entirely remove the lead. If, however, the liquor is made slightly acid, or the sulphate of soda, &c. acidulated, the entire removal of the lead is effected.

We would explain the above anomaly as follows. In order to precipitate the mucilage, gluten, and tannic acid, from raw sugar, an excess of triacetate of oxide of lead must be employed. The sugar abstracts a part of the oxide from the excess, and forms a soluble saccharate of lead; the triacetate being thereby converted into the acetate. When, therefore, sulphate of soda, &c. are added to liquor in the above state, decomposition of the acetate of oxide of lead alone takes place; the saccharate of oxide of lead is not acted on. If now a little acetic acid be added, the saccharate is de-

composed, and changed into the acetate, when it is precipitated by the sulphate of soda, &c.

We are aware that this explanation is contrary to the authority of Berzelius, who states "that saccharate of oxide of lead, is insoluble even in a large quantity of boiling water." However, the following experiment will prove that there is a soluble saccharate of oxide of lead even when the temperature does not exceed 60°. Take a glass tube, 36 inches long, and one inch in diameter, tie a piece of linen over one end, and fill three quarters of the tube with "flake litharge;" prepare some thin liquor by dissolving a pound of refined sugar in 12 pounds of cold water, pour the liquor into the tube, and if what comes through the litharge be tested, it will be found to contain a considerable portion of oxide of lead.

From the necessity of conjoining acids with sulphate of soda, ferrocyanuret of potassium, oxalate of ammonia, &c. it is plain no salts of the above kind can be employed more advantageously than sulphuric, oxalic acids, &c., for the purpose of removing oxide of lead from sugar.

Several of the super-salts, as binoxalate of ammonia, bisulphate of soda, biphosphate of lime, bitartrate of potash, &c., will precipitate oxide of lead from liqour, but the same objection which prevails against the employment of sulphate of soda is equally applicable.

The best agents for the precipitation of oxide of lead, lime, and oxide of iron from liquor, are the diphosphate of lime and neutral solution of phosphoric acid and soda, as recommended in our specification. The explanation we would give as to the action of the diphosphate of lime is, that that body gives off a portion of its acid to the lime contained in the liquor, forming diphosphate of lime, and thereby becomes partly converted into the triphosphate of lime; when the lime is abstracted, the oxide of iron falls down insoluble, or perhaps becomes converted into the diphosphate of oxide of iron; another portion of its phosphoric acid precipitates the saccharate of oxide of lead, forming the insoluble phosphate of oxide of lead. The remainder of the diphosphate exchanges with the acetate of oxide of lead, forming the insoluble phosphate of oxide of lead, and the soluble acetate of lime. A similar explanation attends the action of all the phosphates, including even the animal charcoal of the sugar-house. A very slight modification, however is observed when the soluble phosphates, as triphosphates of soda and basic water (rhombic phosphate of soda,) are substituted for the diphosphate of lime. In this case acetic acid is always set free. This arises from the tendency of phosphoric acid to form triphosphate of oxide of lead.

We will conclude our paper with the following practical advice. The planter and beet-root sugar manufacturer cannot be too much alive to the destructive effects which follow the employment of any alkali or alkaline earth to neutralise the acids existing in the juices of the beet-root and the cane. There is no possibility of neutralising an acid in saccharine solutions by the use of an alkali, &c., without such body being in excess.* The employment of "temper" is nothing but a choice of evils, even to the planter himself. To the refiner, in Europe, the mischief occasioned by its use is incalculable. Its effects can be traced throughout his entire operations. In the raw sugar it darkens the colour by the combination it forms with oxide of iron and sugar. It exerts a most pernicious effect on his grained char-

* The natural acids of the cane juice, &c., should be neutralised by percolation through grained carbonate of lime.

coal, and it is the cause of the "smear" with which he is so frequently annoyed when working up his "poor goods." Br. Ann. Med.

Progress of Civil Engineering.

Museum of Economic Geology.

The laws which, in several of the United States, provide for Geological surveys, do, we believe, very generally, make it the duty of the State Geologists and Naturalists, to provide specimens of the various rocks, minerals, &c., which claim their particular attention, and also designate the places where such collections shall be preserved. That Museums of this Character, may eventually furnish most important *material,* for the study of young Engineers, Architects, Surveyors, and Agriculturists, and, also, the means of illustration in Lectures to the public, on civil economy, and the best means of employing and managing the natural resources of the country, no one, we trust, will be disposed to doubt. There is, on this account, an obvious propriety in establishing at least two Museums of this nature in each State —One at the Capital, accessible to every member of the Legislature and other officers of the Government; and the other, in the most populous city or town in the State, where stated courses of Lectures may be given with the greatest advantage;—and the time, it may be hoped, is not very remote when such lectures will be open, as in the public Schools of France, at a modicum of expense, to all suitable recipients of the knowledge thus attainable.

The following article indicates a spirit of this kind, in operation in Great Britain.

More than a twelvemonth has elapsed since we noticed the first institution of the above national museum, and although its growth, to be commensurate with its importance and extent, must necessarily be slow, we learn with pleasure, from a valued correspondent, that the first branch of it, established in Cornwall, is making rapid and satisfactory progress. The following account of the museum will be read with interest by many of our readers, and we look forward to the time when a similar collection will be formed in the coal and iron districts of our central and northern counties:— G.

"The Museum of Economic Geology was established by his Majesty's Government, under the department of Woods and Works, in consequence of the representation of Mr. De la Beche, that during the progress of the Ordnance Geological Survey, there would be abundant opportunities of procuring specimens illustrative of the mineral wealth of Great Britain, and of the application of geology to the useful purposes of life generally. It is intended that the museum shall be divided into three or four sections. One to contain a series of woods, collected during the progress of the geological survey, to illustrate the connexion of the geological structure of different districts with their agricultural character. This section will also show the best road materials that can be obtained in the different districts and their localities, and will also, in connexion with the Ordnance Geological Maps, show the kind of country likely to be traversed in any proposed lines of canals or roads, and thus be useful in the formation of estimates for such works.

"A second section will illustrate British mining, containing specimens

of the mineral veins, coal beds, &c. of different districts, with such others as illustrate their geological mode of occurrence. We understand that, from the very liberal spirit exhibited by the gentry and mining interests of Cornwall, where the geological survey is at present in progress, this part of the collection is already rich, as respects the lodes of Cornwall, the museum having received from that county donations of the most valuable kind —indeed, such as could not have been procured without the liberal co-operation above noticed. Models of mining machinery are now in preparation to accompany this section of the museum, and there will also be others illustrative of the working of lodes and coal-beds, and of their general mode of occurrence.

"A third section will contain those British rocks which either have been, or advantageously may be, employed in architecture or public works. Among the specimens already collected, we understand there are some porphyries (elvans) of Cornwall of great beauty, and which, from their abundant occurrence, might be extensively employed for ornamental purposes. We believe, however, they have hitherto received little attention, except from Joseph Austen, Esq., who is now causing fine slabs of Withiel porphyry and schorl rock, from the neighborhood of St. Austel, to be cut and polished by machinery for the decoration of his house at Place, Fowey. We are also informed that there are many specimens of the Lizard Serpentine, which show that this beautiful material may advantageously be employed for a variety of ornamental purposes, at comparatively small cost.

"A fourth section will show the various British mineral substances which either have or may be employed as pigments, and which can be used for ornamental purposes, on a small scale, for bijouterie, &c.

"The museum is too much in its infancy to be open to the public at present, and the collections are merely arranged with regard to temporary convenience, but we have little doubt that, when more advanced, this establishment will be found to be one of great public utility for a variety of purposes."

Min. Jour.

Materials for Mortars and Cements.

The study of the nature of different species of mortars, demonstrates that their solidification depends on the formation of silicate of lime, and sometimes also of silicate of alumine. These silicates retain some water, and assume the firmness of stone, whilst the hydrate of lime in excess unites by degrees with carbonic acid; and consequently, solidified mortar may be considered a compound of carbonate of lime and of a zeolite. *Opal*, *pumice stone*, *obsidian* and *pitch stone*, pulverized, form with hydrate of lime a good cement. But only the surface of each grain of *quartz* or *sand*, is transformed into a hydrated silicate; and though this is sufficient to unite the mass, solidification does not take place so promptly. The mass becomes the more solid, the more finely the quartz is pulverized. If the pulverized quartz be mingled with one-fourth part of lime, and, after thoroughly calcining the mixture, it be pulverised and mixed with one-fifth part of lime, it forms a hydraulic cement which becomes so hard as to be susceptible of a polish. Feldspar hardens slowly, and with lime only after five months; but if calcined with a little lime it is much improved. Common potters' clay, which is absolutely worthless in its natural state, affords

with lime, when calcined, provided it contains but little iron, a cement which readily hardens.

Steatite, which has been subjected to a red heat, cannot be made to unite with lime, and thence I concluded that magnesia has a strong affinity for silicic acid, attempted to employ calcined dolomite, in the place of ordinary lime, and found that it surpassed it, both as a material for ordinary mortar, and also for a hydraulic cement. I obtained a good mortar with this last material and calcined marl.——Fuchs. *Bérzelius' Jahrsbericht.*

Mag. Pop. Sci.

Progress of Physical Science.

Instructions for making and Registering Meteorological Observations.

Continued from p. 197.

"*Of the Temperature of the Sea.*—The surface temperature of the water at sea should be registered, as a matter of course, with the same regularity and at the same hours as the barometer and thermometer. It is more conveniently (and with quite accuracy enough for the purpose) obtained by taking up a bucketful of the water and stirring round the thermometer in it. Whenever a change to the extent of 2° Fahr. appears to have taken place since the last observation, a fresh bucketful should be taken up, and the observation repeated. It should also be noticed whether rain has fallen since the last observation. A sudden depression of 3° or 4° indicates the near approach of land. In a voyage lately made from England to the Cape of Good Hope, the temperature of the surface water fell at once 9° Fahr., on approaching within a few miles of the entrance of Table Bay.

"The temperature of the sea at considerable depths can hardly be regarded as a subject of ordinary meteorological inquiry and regular registry, though undoubtedly one of much physical interest; for which reason it is not considered necessary to dwell further on it.

"*Of the Hygrometer, &c.*—In the absence of Daniell's Hygrometer, or of ether to cool it, the degree of dryness of the air may be ascertained by observing the temperatures marked by two thermometers suspended freely side by side (but not in contact) in the shade, and completely defended from all radiation *to* or *from* the *sky*, the one having its bulb and stem naked, the other with the bulb and lower part of the stem wrapped in linen or cotton, and thoroughly wetted with pure spring or rain water. The temperatures indicated by both should be noted when the wetted thermometer refuses to sink lower, and the conclusions left for subsequent calculations. The naked thermometer may be the 'External Thermometer' itself, in which case a coated thermometer may be kept always suspended near it, completely screened, as above mentioned, and wetted some minutes previous to the regular daily readings.

"If a hair hygrometer be used, its points of absolute moisture and dryness should be frequently ascertained, as they are apt to change. The former may be found by keeping it some time in a close covered jar lined with wet blotting paper, and having water in it, and noting the point of moisture beyond which it refuses to go. The latter, by keeping it in the same manner in a jar perfectly air-tight, over fresh burnt quick-lime, till it refuses to indicate a higher degree of dryness.

"The best measure of the *momentary evaporating power* of the air seems to be the depression of the wetted thermometer below the dry one. But

the *actual evaporation* from a given surface is quite another thing, and a question may very reasonably be raised, how far any useful approximation to a knowledge of the total evaporation from an extensive and diversified surface, unequally moistened, and variously exposed to the sun, defended by clouds, or refreshed by dews, *can* be obtained by any small or local experiments.

"The Rain-gauge is an instrument of such extremely easy construction, that any person who lives near a tinman can procure one. In arid climates, it must, however, be remembered, that it will often need examination and cleansing, owing to long intervals of disuse in which insects and dust may lodge in it. It will often happen, too, that the slight train of one day, if left unregistered, may be entirely lost by evaporation in the next,—nay, that slight and transient showers may never enter it, being evaporated from it as they fall. The effect of copious dew, too, must be separated from that of rain, so that the mere registry of the contents of the gauge is not of itself a sufficient indication whether rain has fallen in the night or not. However, there are usually good reasons for decision on this point from other indications. Attention to the amount of dew is very necessary, not only because the meteorological questions involved are of a high degree of interest generally, but because in arid climates the dews are of almost as much importance to the maintenance of vegetation as the rain.

"In stating the quantity of rain daily received in the gauge, the height of the receiver above the soil should be mentioned, experience having shown that the quantities of rain which actually fall on a given area on the ground, and at a very moderate height above it, often differ materially. In some localities and circumstances, the rain-drops receive accession from the air as they descend, in others they undergo partial evaporation. The former is generally the case in cool moist climates,—the latter may be expected in this country.

"*Of the Wind.*—The points most important to remark respecting the wind, are,—

"1st. Its average intensity and general direction during the several portions of the day devoted to observation and registry.

"2ndly. The hours of the day or night, when it commences to blow from a calm, or subsides into one from a breeze.

"3rdly. The hours at which any remarkable changes of its direction take place.

"4thly. The course which it takes in veering, and the quarter in which it ultimately settles.

"5thly. The usual course of *periodical winds*, or such as remarkably prevail during certain seasons, with the law of their diurnal progress, both as to direction and intensity—at what hours, and by what degrees, they commence, attain their maximum, and subside, and through what points of the compass they run in so doing.

6thly. The existence of crossing currents at different heights in the atmosphere, as indicated by the course of the clouds in different strata. In observing these, it is advisable to fix the eye by some immovable object, as some point of a tree or building, the sun, or the moon; otherwise mistakes are apt to arise.

"7thly. The times of setting-in of remarkable hot or cold winds,—the quarters from which they come, and their courses, as connected with the progressive changes in their temperature.

"8thly. The connexion of rainy, cloudy, or fair weather, with the

quarter from which the wind blows, or has blown for some time previous.

"9thly. The usual character of the winds as to moisture or dryness, not as deduced from mere opinion or vague estimation, but from actual observation of the hygrometric state of the atmosphere during their prevalence.

"Among these particulars it will be seen that some are of a nature susceptible of daily observation and registry, while others call for an exercise of the combining and inductive faculty on the observer's part, and cannot be made out otherwise than by continued attention and habitual notice of phenomena, with a view to the investigation of their laws. The general impression left upon the mind as to any of the points of this kind above enumerated, by the occurrences of the past month, will therefore be more properly stated, in the way of summary remarks at the end of monthly registers, than as entries under particular days.

"*Of the State of the Sky.*—In describing the state of the sky as to clouds, &c. the observer will bear in mind that it is only in that region of the sky which is vertically above him that the true forms and outlines of the clouds are exhibited, and the area they cover, as well as the intervals between them distinctly seen. As they approach the horizon in any direction, their extent is foreshortened by perspective, their apparent magnitude diminished by distance, and their intervals covered in, and hidden by their mutual interposition. In estimating, therefore, the quantity of clouds in the sky, regard must be had to this, and our judgment should rather be formed on a view of the region extending from the zenith every way half way down to the horizon, than from the aspect of the heavens below that limit. It would be better to notice both, and state, separately, the proportions in which each are covered, and the quarter of the horizon towards which the chief masses in the lower region lie.

"The general aspect of clouds, as classed under the heads Cumulus, Cirrus, Stratus, &c., should be noticed, and especially the height of this inferior surface, or the level of the *vapour-plane*, should be estimated. In a mountainous region this is easy, so long as the vapour-plane is below, or not far above, the summits of the hills, and in such regions the formation and dissipation of clouds in the neighborhood of the mountain-summits, under the influence of certain winds, form a subject of study of a highly curious and interesting nature.

"The formation of clouds at night, during calm weather, under the influence of a gradually descending temperature, is another point worthy of attention. It frequently happens that, without any perceptible wind, the sky will suddenly become hazy in some one point, and the haze condensing and spreading, in all directions, without a wind, the whole heaven will become overcast in a remarkably short time. The same thing will sometimes occur nearly at the same hour for many nights in succession. Such phenomena should be noted whenever they occur.

"*Of Thunder and Lightning, and of the Electrical state of the Air.*—Connected with this part of the subject is the observation of shooting-stars and luminous meteors. Remarkable ones should be noticed, and the moment of their appearance, their direction, duration, length of path, and *course among the stars*, ascertained and noted, with the phenomena of their increase and decay of light, apparent size, separation into parts, trains left behind, &c. The *general* direction (if any) which they observe on particular nights, is a point also to be attended to. When these splendid phenom-

ena occur frequently and brilliantly in clear skies, there can be no doubt of their affording an available method of ascertaining the differences of longitude of the most distant stations, if duly observed by persons furnished with means of ascertaining the time.

"Thunder-storms, of course, will be noticed when they occur, under the general head of the weather, but it is of consequence also to notice distant lightning, not accompanied with thunder audible at the place of observation (by reason of its great distance,*) especially if it takes place many days in succession, and to note the quarter of the horizon where it appears, and the extent it embraces. In an actual thunder-storm, especial notice should be taken of the quantity of rain that falls, and of the fits or intermittences of its fall, as corresponding, or not, to great bursts of lightning, as also of the direction of the wind, and the apparent progress of the storm with or against it.

"Observations of the electrical state of the air in serene weather are unfortunately too much neglected. The apparatus they require is simple, and by no means costly, and may be constructed, indeed, by any one for himself with ease.

"Attention to the accumulation of regular and daily observations of a definite and numerical character is, in the first instance, of the highest importance. In order that such observations may be registered with uniformity and ease, printed skeleton-forms should be prepared and distributed to all persons who may be willing to undertake their filling up. These may comprise only the registers of the barometer and its attached thermometer, with that of the external thermometer, and a column of remarks for wind and weather, as being the most essential and indispensable elements of meteorology; but it is in the power of any one who pleases to supply additional information, and to those who have leisure, instruments, and inclination for the task, it is particularly recommended to observe regularly the wet thermometer, the self-registering thermometer, and weekly or monthly thermometers buried at different and progressive depths beneath the surface of the soil.

"The printed forms should provide for the arithmetical convenience of casting up the *means* for each month. In doing so, it is requested that care may be taken to verify the results by repetition, and (that usual sources of error may not escape notice;) it is recommended in every instance, before adding up the columns, to look down each to see that no obvious error of entry (as of an inch in the barometer, a very common error, or, what is more difficult of detection, an error in the first decimal place,) shall remain to vitiate the mean result. It is perhaps unnecessary to do more than mention the precaution of *counting* the days in *each* column on which observations occur, so as to admit of no mistake in the *divisor*, and to use throughout the decimal arithmetic in calculating the mean results. Care and exactness in these points will, in most cases, add greatly to the value of the registers, as it will be quite impracticable for any person, should observations accumulate in masses, unreduced or erroneously reduced, to undertake the overwhelming task of recomputing them.

"Although not, strictly speaking, a branch of meteorology, yet, as observations of the tides are now earnestly desired in every part that they visit,

*"Thunder can scarcely ever be heard more than 20 or 30 miles from the flash which produces it. Lightning, on the other hand, may be seen (or at least its reflection on the clouds, forming what is called *sheet lightning*,) at the distance of 150 or 200 miles."

it would be especially desirable to obtain regular observations of the time and height of high and low water on the coasts, &c., according to the rules, and on the plan, proposed by Mr. Whewell, in his late researches on this subject."

Mag. Pop. Sci.

On the Stony Matters which are employed in China in the time of Famine, under the name of Flour of Stone. By M. Biot.

The details which were communicated to the Academy of Sciences by M. de Humboldt concerning the existence of a stony substance, which is sometimes employed in Lapland, in the time of dearth, have recalled to my recollection the notice of a similar fact which has lately reached us from China, and which was reported in the correspondence of the missionaries. My son having likewise found the same fact, attested at many different periods in the Japanese *Encyclopédia*, with the dates attached, I requested him to translate the passages which related to the subject; and it has occurred to me that the Academy would regard with interest the collection of these documents concerning the employment of the article in a way much more general than we are usually led to believe.

The Japanese Encyclopedia, book lxi., "Upon Stones and Minerals," contains an article entitled *Chi Mien* or *Stone flour*, of which we now present a translation; and in which it will be seen the same superstitious ideas prevail which M. de Humboldt had remarked in Laponia. "The *Pen-tsao-Kang-mou*"* remarks, "The flour of stone is not an ordinary substance, but a miraculous production. Many declare that it is produced in the time of famine. Under the Emperor *Hien-Tsong*, of the dynasty of *Tang*, in the period of *Tien-pao*, the third year (answering to A. D. 744,) a miraculous spring issued from the earth, and stones were decomposed and converted into flour." To the letter-press of this extract is conjoined a wood-cut, which represents the spring issuing forth in cascades, and the stones breaking up into slender threads, but these are so incorrectly indicated that it is not possible to draw any mineralogical inferences.

We subjoin some additional notices. "Under the Emperor of *Hian-Tsong*, of the same dynasty, in the period *Yuen-ho*, fourth year (A. D. 809,) stones were decomposed and became meal." Under the Emperor *Tching-Tsong*, of the dynasty of *Soung*, in the period *Tsiang-fou*, fifth year (A. D. 1012,) "a marrow was produced from stones which resembled flour." Under *Jin-Tsong*, in the period *Kia-yeou*, seventh year (A. D. 1062,) "the flour of stone was produced." Under *Tchi-Tsong*, in the period *Yuen-fong*, third year (A. D. 1080,) "stones were decomposed and became flour. All these kinds of flour were collected and eaten by the poor."

We now add the statement, made in 1834, by one of the Chinese missionaries, M. Mathieu-Ly, who is established in the province of *Kiang-Si*.† The facts which he describes relate to the same year 1834, and to the three

* This work is a collection of Chinese Natural History, compiled about A. D. 1575, from treatises which were still more ancient. M. S. Julien having kindly communicated to my son his copy of the *Pen-tsao-Kang-mou*, the quotation given in the Japanese Encyclopedia has been compared with the original text, and found to be accurate. Many of the places named are situated in the Northern Province called *Chan-Si*, where, the cold is often severe during the winter; others belong to the maritime province of *Chan-tong* and *Kiang-Nan*, near the mouth of the Yellow River. The provinces of *Hou-Kouang* and *Kiang-Si*, concerning which the missionaries attest the same fact, are different from these, and are situated in the valley of the Blue River.

† See Annales de la propogation de la Foi, No. xlviii. p. 85, Sept. 1836.

preceding, so that they coincide with those mentioned by M. Retzius regarding Laponia. "Many of our converts will assuredly die this year from want; and it is God alone who can provide a remedy for so many and such aggravated necessities; all the crops have again been carried away by the overflowing of the rivers. For a period of three years now, an immense number of persons have supported themselves upon the bark of a tree which is found in the country; whilst others eat a light earth of a white colour, which has been discovered in a mountain. The earth can only be bought with silver, and it is not every one that can procure it. These wretched people first sold their wives, their sons and daughters, they then sold their tools, and the furniture of their houses; and even these they have finally demolished that they might sell the timber-work. Many of these unfortunate people were really rich four years ago."

Another missionary, M. Rameaux,* writing concerning the province of *Hon-Kouang*, about the middle of the year 1834, supplies details which are not less deplorable. "The district *Fan-Hien*, he remarks, contained about a thousand converts; but their number has been exceedingly reduced by famine. A great number have come to me to demand the last sacraments. They calculate their resources, and accurately know, almost to an hour, the number of days they can subsist. They receive the sacrament of extreme unction when their means are exhausted, and then having nothing to eat, they calmly wait the moment of their demise."

Clearly to apprehend the cause of these calamities, and their frequent returns among an industrious society, which is chiefly agricultural, and has had the blessing of a steady government for a long course of ages, it is necessary to recollect that many provinces of China, more extensive than the half of the whole kingdom of France, are great uniform plains, traversed by immense rivers, whose beds are ever and anon choked up by the deposits which are left by the waters, so that it is necessary constantly to confine them by high dikes, which are maintained with immense labour. The provinces of *Hou-Kouang* and of *Kiang-Si*, for example, which have now been named, are thus traversed by the Blue and other great rivers. These circumstances afford every facility for irrigation, develop an agriculture in which industry is pushed very nearly to its limit, whereby the most abundant harvests are produced, especially of rice, which is cultivated even up the slopes of the hills, the water being forced up by hand-engines. So long as this state of things continues, the necessary result is an immense production of the means of subsistence, which leads to a corresponding development of the population. But if once the waters so far increase as to run over the dikes, they spread over the plain, inundate it, and swallow up a portion of the population: whilst those who escape the disaster, finding themselves ruined, and deprived of all their resources so long as the waters cover the soil, remain a prey to all the miseries which the missionaries describe, and, finally, in immense numbers, actually perish from hunger. This cause, conjoined with the awful catastrophes produced by earthquakes, which seem to be more frequent, more violent, and especially more widely spread in China than in most other regions of the globe, enables us, in a great degree, to understand the sudden vicissitudes which, as the history of China attests, so often occur in the number of the population of this vast empire; vicissitudes whose proportionate number bears no relation to the regular

* Ann. de la propogation de la Foi, No. xlviii, p. 61.

law of European population, as may be seen in a memoir inserted in the *Journal de la Société Asiatique.**

Ed. New Philos. Jour.

On the Organic remains in the Coal Formation at Wardie, Scotland. By Robt. Paterson, M. D.

It is now almost universally admitted, that coal has resulted from the distribution of vegetable remains over areas of greater or less extent upon a previously deposited surface of sand, or argillaceous silt, and that after the entombment of this mass of vegetable matter, other layers of mud and clays were deposited on it; and this operation must have continued for a considerable length of time, during which it is more than probable that an abundant vegetation existed at no great distance from the spot where this process was taking place.

These changes are most likely to have gone on in estuaries or indentations of the land, into which this mass of vegetable matter was brought by rivers, while the sea made occasional, or in some instances continuous, incursions. In this manner we can easily see how, by accidental circumstances, the productions of the land or sea in greater or less abundance are occasionally met with in the strata of the carboniferous series, and how in one coal district an examination of its organic remains may afford one individual reason to believe, that the strata were chiefly deposited in salt water; a second, from the examination of a different locality, that they are entirely fluviatile, or probably he may imagine them lacustrine; while a third may see the same organic remains which have given rise to the two former opinions so mixed up and incorporated together in another place, as to leave no doubt on his mind that the two former cases were only extreme degrees of what he had noticed.

Ibid.

"*An account of a Well at Beaumont Green in the County of Hereford fifteen miles from London, about a mile to the west of the road to Ware;*" *by* J. Mitchell, LL. D., F. G. S.

This well was dug in 1833, in the premises of Mr. Munt, a magistrate of the county, and the information respecting it obtained from two gentlemen accustomed to collect evidence with the strictest scrutiny.

The strata passed through, were one foot vegetable mould, 15 feet gravel, one foot sand with flints, 83 feet gravel clay, 15 feet blue sand with black pebbles, 10 feet blue clay, 1½ feet fine soft white sand, or 126½ feet down to the chalk, which was penetrated for 40 feet, when a spring was met with; but the digging continued 17 feet lower to form a reservoir of water, and this was favoured by making the excavation in the chalk of a bell shape, but above this the well was 4½ feet in diameter.

When the well was dug the weather was dry, but on this becoming very wet the 15 feet stratum of blue sand and black pebbles began to emit foul air, by which one of the well-diggers was suffocated in descending. A hawk flying over the well fell into it, and a similar fate befell smaller birds, also wasps, bees and flies. On closing up the mouth of the well, with the exception of an orifice an inch in diameter, so powerful was the force of the issuing current of foul air that it raised a weight of twelve ounces of lead.

* Memoire sur la population de la Chine et ses Variations, depuis l'an. 2400 avant l'ère Chrètienne, jusqu'au 13e Siècle après; par Edouard Biot.

In fine weather there was on the contrary a strong draft down into the well.

Eight months afterwards the well was again entered when the stratum of blue sand and black pebbles appeared forming into plumb-puddling stone. The well was rendered safe by bricking it down to the chalk, and applying a thick coating of compost over the whole. Dr. Mitchell explains the phenomena by observing that the foul air was no doubt sulphuretted hydrogen, produced by the decomposition of water and iron pyrites. After long-continued rain, water penetrating into the bed dislodged the gas accumulated in the interstices where it was formed; while after dry weather had continued for some time, the openings produced in this bed on drying up would draw for a short time a supply of air to fill up the vacuities, and hence the draft observed to pass down into the well. The whole of the neighbouring district, to the extent of four miles, is called by the well-diggers, foul country. Similar phenomena were observed in digging a well on the opposite hill at Applebury, and also in forming some wells in the immediate vicinity of London. Ibid.

Mechanics' Register.

Plumbago and Black Lead Pencils.

There is only one purpose to which this form of carbon is applied in the solid state, viz., for the manufacture of black lead Pencils, and its adaptation to this end depends on its softness. In the state of a powder, plumbago is used to relieve friction. Its power in this way may be illustrated by rubbing a button first on a plain board, five or six times, and applying it to a bit of phosphorus, the latter will immediately burn. When rubbed on a surface covered with plumbago, double or triple the friction will be required to produce the same effect. One of the most remarkable circumstances connected with plumbago, is the mode in which it is sold. Once a year the mine at Borrowdale is opened, and a sufficient quantity of plumbago is extracted, to supply the market during the ensuing year. It is then closed up, and the product is carried in small fragments of about three or four inches long, to London, where it is exposed to sale, at the black lead market, which is held on the first Monday of every month, at a public-house, in Essex-street, Strand. The buyers, who amount to about seven or eight, examine every piece with a sharp instrument, to ascertain its hardness—those which are too soft being rejected. The individual who has the first choice pays 45s. per pound, the others 30s. But as there is no addition made to the first quantity in the market, during the course of the year, the residual portions are examined over and over again, until they are exhausted. The annual amount of sale is about 3000*l*. There are three kinds of pencils, common, ever-pointed, and plummets. The latter are composed of one-third sulphuret of antimony, and two-thirds plumbago. The first part of the process is sawing out the cedar into long planks, and then into what are technically termed tops and bottoms. The second, sawing out the grooves by means of a fly-wheel. The third scraping the lead on a stone, having been previously made into thin slices, to suit the groove: introducing it into the groove, and scratching the side with a sharp-pointed instrument, so as to break it off exactly above the groove. The fourth, glueing the tops and bottoms together, and turning the cedar cases in a gauge. The *ever-pointed* pencils are first cut into thin slabs, then into

square pieces, by means of a steel gauge. They are then passed through three small holes, armed with rubies, which last about three or four days. Steel does not last above as many hours. Six of these ever-pointed pencils may be had for 2s. 6d. If they are cheaper than this, we may be sure that they are adulterated. In Paris, when you buy a sheet of paper in a stationer's shop, some of those pencils are added to the purchase. Now, these are formed of a mixture of plumbago, fuller's earth, and vermicelli. Genuine cedar pencils must cost 6d. each. If they are sold at a lower price they must be formed from a mixture, not from pure plumbago. Pencils are, however, sold as low as 4½d. a dozen. There is no patent which has been more infringed on than that of Mordan's, for ever-pointed pencils. Birmingham is the source of this infringement, where they are sold as low as ¾d. each, formed of composition. A thousand persons are now engaged in the manufacture of these pencils and pencil-cases. These facts were stated by Dr. Faraday, at the Royal Institution, April 22.—*Arcana of Science.*

Min. Jour.

Edge Rails.

The edge rail has now entirely superseded the tram or train-plate, and is used in all railways worked by locomotive engines. This form of rail causes much less friction to the wheels, there being considerably less surface of the former coming in contact with the latter. These rails are made of wrought iron, in 15-feet lengths, with an upper flanch slightly curving from the middle to the sides; the weight of rail is regulated by the tonnage passing along the line. On the Stockton and Darlington, Manchester and Liverpool, and Leeds and Selby Railways, the weight per lineal yard of the original rails is 35 lbs. On the Manchester Railway, however, rails of 75lbs. are being substituted. The size of the 35lb. rail is $3\frac{1}{2}$ inches in depth, $2\frac{1}{4}$ inches as to the width of the upper flanch, and the upright portion three-quarters of an inch thick. The original rails of the London and Birmingham Railway, are 50 lbs. in weight, as also those of the Greenwich Railway; but on the former line 75lb. rails are being laid down, to a considerable extent. The Manchester and Bolton rail is 50lb. to the yard, but differs in shape from those used on every other railway. The top flanch is $2\frac{1}{4}$ inches wide, the bottom flanch $4\frac{5}{8}$ inches wide, the depth $2\frac{6}{10}$ inches, and the thickness of the middle portion three quarters of an inch.—*Whishaw's Analysis of Railways.*

Min. Jour.

Steel Letter Press Engraving.

A young artist of Vienna, named von Sieglander, has, we are informed by the German papers, recently discovered a process by which he can execute engravings in the style of copperplate, which can, nevertheless, be printed with letter-press in the same manner as wood cuts. This invention may prove of some importance. The Hamburgh Correspondent tells us with as much solemnity as it speaks of the invention, that Mr. Ficker, Professor of Asthetics, at the High School of Vienna, has already given it the name of *Chalcoxlyography.*

Mec. Mag.

LUNAR OCCULTATIONS FOR PHILADELPHIA, DECEMBER 1837.

Angles reckoned to the right or westward round the circle, as seen in an inverting telescope. ☞ For direct vision add 180° ☜

Day.	H'r.	Min.	Phase	Star's name.	Mag.	from Moon's North point.	from Moon's Vertex.
2	6	2	Im.	33 Capricorni	6.	130	150
2	7	11	Em.			293	327
5	4	43	Im.	9 Piscium	5.	103	71
5	5	50	Em.			333	315
12	14	56	Im.	c, Aurigæ	6.	125	182
12	15	50	Em.			214	272
17	16	43	Im.	*l*, Leonis	6.	350	345
17	17	26	Em.			290	302
24	20	45	Im.	α Scorpii	1.	73	57
24	22	4	Em.			244	243

Meteorological Observations for July, 1837.

Moon.	Days.	Therm. Sun rise.	Therm. 2 P.M.	Barometer. Sun rise.	Barometer. 2 P.M.	Wind. Direction.	Wind. Force.	Water fallen in rain.	State of the weather, and Remarks.
				Inches	Inches			Inches.	
⊗	1	70°	86°	29.70	29.70	W.	Moderate.		Lightly cloudy—do. do. aur. bor.
	2	64	78	80	85	NW.	do.		Clear—do.
	3	64	76	80	70	W.	do.		Partially cloudy—do. do.
	4	66	78	80	80	W.	Brisk.		Clear—do.
	5	66	81	70	70	W.	Moderate.	1. 5	Cloudy—shower.
	6	64	82	50	60	E W	do.		Cloudy—flying clouds.
	7	67	71	80	83	W.	do.		Cloudy—do.
	8	62	68	80	80	[illegible]S.	do.	.45	Rain—cloudy.
☾	9	60	75	90	30.00	NW.	do.		Clear—do.
	10	58	76	30 00	29.95	W.	do.		Clear—do.
	11	66	76	29.85	80	W.	do.	.15	Cloudy—shower.
	12	62	74	80	85	E	Brisk.		Cloudy—flying clouds.
	13	59	78	95	30 00	E.S.E.	Moderate		Clear—do.
	14	61	82	85	29.75	W.	do.		Clear—do.
	15	66	84	70	70	W.	Brisk.		Clear—do.
	16	63	78	76	85	W.	Moderate		Lightly cloudy—clear.
⊕	17	64	80	30.10	30.10	NW.	do.		Clear—do.
	18	66	80	10	5	S.	do.		Cloudy—clear.
	19	66	78	29.90	29.86	S.	do.	.2	Lightly cloudy—do. do.—shower.
	20	68	82	80	80	W.	do.		Clear—Lightly cloudy.
	21	64	80	90	90	W.	do.		Clear—do
	22	62	80	95	95	W.	do.		Clear—do.
	23	68	82	80	80	S.	do.	.2	Cloudy—do.—shower.
☽	24	72	84	65	60	SW.	do.		Lightly cloudy—do. do.
	25	61	76	64	65	W	Brisk.		Partially cloudy—do. do.
	26	60	67	65	65	W.	Moderate	.45	Clear—rain.
	27	60	77	60	64	W	Brisk.		Clear—do.
	28	63	82	75	80	W.	Moderate		Clear—do.
	29	68	84	80	76	W.	do.		Partially cloudy—clear.
	30	65	78	85	85	SE.	do.		Cloudy—do.
	31	69	80	80	80	SE.W.	do.		Cloudy—lightly cloudy.
	Mean	64.35	78.45	29.81	29.81			2.14	

	Thermometer.	Barometer.
Maximum height during the month	86.00 on 1st.	30.10 on 17th 18th.
Minimum do.	5.40 on 10th	29.50 on 6th
Mean do.	71.42	29.81.